NOTICE

All drawings located at the end of the document.

Resource Conservation and Recovery Act Post-Closure Care Permit Application

For U.S.D.O.E.-Rocky Flats Plant
Hazardous & Radioactive Mixed Wastes

CO7890010526

5 October 1988

Volume XII

[redacted] Brl (4) 2/7/90

REVIEWED FOR CLASSIFICATION/UCNI
By
Date 4/1/92

ADMIN RECORD

A-SW 000-31

Resource Conservation and Recovery Act

Post-Closure Care Permit Application

For U.S.D.O.E.-Rocky Flats Plant
Hazardous & Radioactive Mixed Wastes

CO7890010526

5 October 1988

Volume XII

Prepared by:

ROCKWELL INTERNATIONAL

North American Aerospace Operations

In Association with:

WESTON

Chen & Assoc , Inc

REVIEWED FOR CLASSIFICATION/UCNI
By [illegible]
Date 4/1/92

[redacted]

BM (4)
2/9/90

CO7890010526

Date: October 5, 1988
Revision No.: 1

RCRA POST-CLOSURE CARE PERMIT CONTENTS OF VOLUMES

WEST SPRAY FIELD

CLOSURE PLAN

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

OCTOBER 3, 1988

ROCKWELL INTERNATIONAL
NORTH AMERICAN AEROSPACE OPERATIONS
ROCKY FLATS PLANT

CLOSURE PLAN

WEST SPRAY FIELD

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO
OCTOBER 3, 1988

Rockwell International
North American Aerospace Operations
Rocky Flats Plant
P.O. Box 464
Golden, Colorado 80402-0464

Roy F. Weston, Inc.
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228

Chen & Associates, Inc.
96 South Zuni Street
Denver, Colorado 80223

Prepared for the U.S. Department of Energy

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Description of the Rocky Flats Plant

1.1.1 Location and Operator

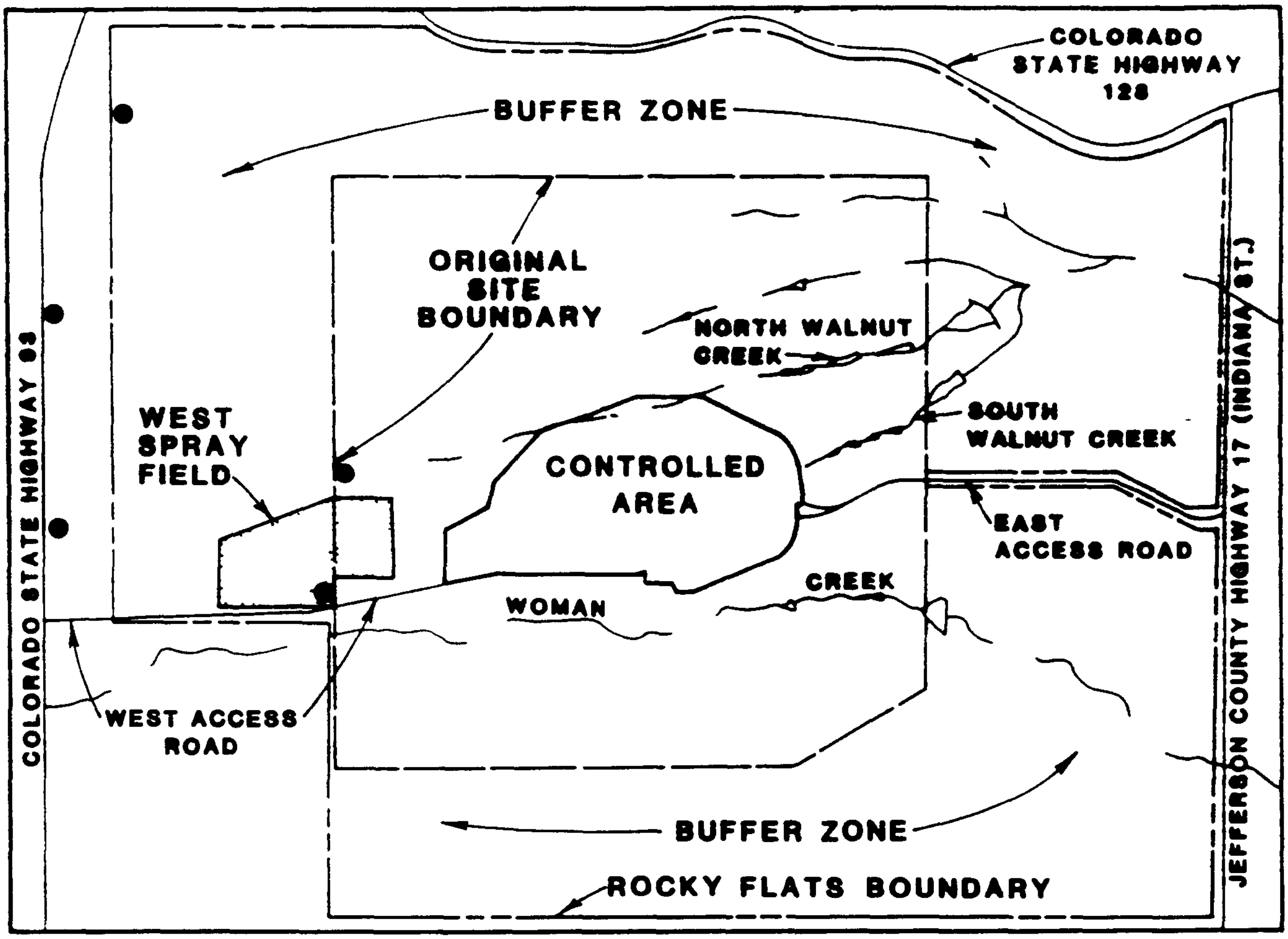
The U.S. Department of Energy's Rocky Flats Plant is located in north-central Colorado, northwest of the City of Denver (Figure 1-1). The Plant is located in Sections 1 through 4 and 9 through 15 of T. 2 S., R. 70 W. The facility's EPA identification number is CO7890010526. The mailing address is:

U.S. Department of Energy
Rocky Flats Plant
P.O. Box 928
Golden, Colorado 80402

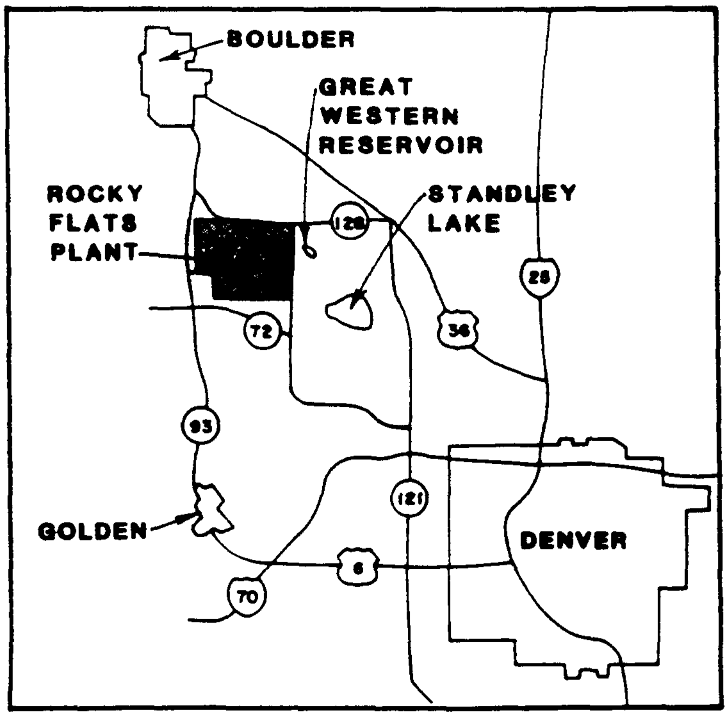
The facility contact is:

Albert E. Whiteman, Area Manager
Phone: (303) 966-2025

The facility covers approximately 6,550 acres of federally owned land in northern Jefferson County, Colorado, which is centered at 105^{o} 11' 30" west longitude, 39^{o} 53' 30" north latitude. The facility is approximately 16 miles northwest



APPROXIMATE SCALE 1"=3,300'



APPROXIMATE SCALE 1"=40,000'

N

● ANNUAL ENVIRONMENTAL SOIL SAMPLING LOCATION (APPROXIMATE)

6 064 87	Chen & Associates	VICINITY MAP	Fig 1-1

of Denver and nine to 12 miles from the neighboring communities of Boulder, Broomfield, Golden and Arvada. It is bounded on the north by State Highway 128, on the west by a parcel of land east of State Highway 93, on the south by a parcel of land north of State Highway 72 and on the east by Jefferson County Highway 17. Access to the plant is from an east access road exiting from Jefferson County Highway 17 and a west access road exiting from State Highway 93.

The facility is situated at an elevation of approximately 6,000 feet. It is on the eastern edge of a geological bench known as Rocky Flats. The bench is approximately five miles wide and flanks the eastern edge of the foothills of the Rocky Mountains.

1.1.2 Mission

The Rocky Flats Plant is a government-owned and contractor-operated facility. It is part of a nationwide nuclear weapons research, development and production complex administered by the Albuquerque Operations Office of the U.S. Department of Energy (DOE). The prime operating contractor for the Rocky Flats Plant is Aerospace Operations of Rockwell International.

The facility produces components for nuclear weapons; therefore, its product is directly related to national defense. The facility fabricates components from plutonium, uranium, beryllium and stainless steel. Other production activities include chemical recovery and purification of recyclable transuranic radionuclides, metal fabrication and assembly and related quality control functions. Other activities include research and development in metallurgy, machining, non-destructive testing, coatings, remote engineering, chemistry and physics. Parts made at the plant are shipped elsewhere for final assembly (U.S. Department of Energy, 1987a).

1.1.3 Brief History

Construction of the Rocky Flats Plant was approved by the U.S. Government in 1951 as an addition to the nation's nuclear weapons production complex. Operations began in 1952 under direction of the Atomic Energy Commission. The original facility covered an area of approximately 2,520 acres (Figure 1).

A buffer zone was added in 1974-1975 to enlarge the plant to it present size of approximately 6,550 acres. The buffer zone had been used for grazing cattle and horses and is enclosed within a cattle fence which is posted with signs indicating restricted access. Two office buildings, a warehouse, firebreaks, holding ponds along three water courses, environmental monitoring instrumentation, a sanitary landfill area, a salvage yard, power lines, inactive gravel pits, clay pits and two target ranges are located in the buffer zone. Additionally, a former wind energy test site now used as an office building and a Ground Wave Emergency Network (GWEN) tower being installed by the U.S. Air Force are located in the buffer zone.

Major facility structures are located in a 400-acre controlled area near the center of the property. Production, research and development facilities at the plant are located in the controlled area which contains approximately 134 structures with a combined floor space of approximately 2.67 million square feet.

1.2 Description of the West Spray Field

1.2.1 Introduction

The west spray field is located within the Rocky Flats property boundary just west of the controlled area as shown on Figure 1-1. A topographic map of the West Spray Field is shown on Figure 1-2.

The area was operated by Rockwell from April 1982 to October 1985. During operation, excess liquids from solar evaporation ponds 207-B North and Center were pumped periodically to the west spray field for spray application. Based on interviews, direct application of the liquids occurred in portions of the spray field designated Areas 1, 2 and 3 for the purpose of this report (Figure 1-3). This conclusion is supported by examination of aerial photographs. The photographs indicate some surface run-off occurred into the unnumbered areas within the approximate location of the spray field's exterior boundary. Limited quantities of windblown spray probably also contributed to the pattern observed on the aerial photographs.

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000294

Titled: WEST SPRAY FIELD TOPOGRAPHIC MAP

FIG 1-2

Fiche location: A-SW-M14

Application was initially by two moving spray irrigation lines mounted on metal wheels with stationary impulse heads. One of these lines is now anchored in Area 2. The other line which was damaged by wind is located west of the spray field and is no longer in use. In Area 1, the portable lines were initially replaced by the two westernmost fixed lines, and in 1985 a third fixed irrigation line. These lines were fitted with stationary impulse heads. A spray impulse cannon was placed in various locations of Area 3 after use of the portable irrigation systems stopped (Shirk, 1986). The location of Area 3 is not confirmed by the aerial photographs due to limited usage and various locations used for the spray impulse carrier, but is known from operating personnel.

1.2.2 Size

The west spray field boundary covers an area of approximately 4,577,000 square feet or approximately 105.1 acres. Three areas, 1, 2 and 3, appear to have received directed application (Figure 1-3). The boundaries of Areas 1, 2 and 3 and the exterior boundary of the spray field have been located based on interviews and aerial photograph interpretation.

Area 1 is approximately 1,553,000 square feet or about 35.6 acres in surface area. This area encloses three fixed irrigation lines with a spray width of 80 feet and average length of 1,524 feet. This results in a spray area of approximately 8.4 acres for the three lines. Area 1 is the general area of application for the original portable irrigation lines (Aerial Photograph, 1986 and Shirk, 1986).

Area 2 is approximately 1,360 feet by 80 feet in size with a surface area of 109,000 square feet or about 2.5 acres. This area corresponds to the estimated application area of the single anchored portable irrigation line (Aerial Photograph, 1986 and Shirk, 1986).

Area 3 is an oval area made up of small circular application areas all with a radius of approximately 100 feet, the estimated maximum radius of the impulse cannon. The surface area is approximately 140,000 square feet or about 3.2 acres.

The total combined area of direct application is about 41.3 acres or about one-third of the total west spray field boundary.

1.2.3 Topography

The natural ground surface in the spray field is nearly level to gently sloping down to the east and east-northeast. The slopes of the irrigated areas and surface runoff areas range between approximately one percent and three percent. There are a number of minor drainages in the west spray field which trend to the east. Relief within the drainages is on the order of one to two feet.

The topography of the West Spray Field was altered during use of the field in response to NPDES Permit technical violations. A series of small ditches and berms were constructed just east of Area 1 to prevent surface runoff of water. These ditches and berms would pond the water on the West Spray Field until infiltration could occur.

1.2.4 Soil Types

The near-surface soils in the west spray field and surrounding areas as described by the Soil Conservation Service (U.S. Department of Agriculture, 1984) consist primarily of 13 inches of very cobbly, sandy loam overlying 34 inches of very gravelly clay, very gravelly, sandy clay and very gravelly, clayey loam. The lower material is underlain by 13 inches of very gravelly, sandy, clayey loam. Table I presents descriptions and typical properties of the upper five feet of soil in the west spray field. These soil characteristics have been supported by field work conducted in 1988 that generally confirmed the above general depths and soil types.

Typical infiltration rates range from two to six inches per hour in the upper layer, 0.06 to 0.2 inches per hour in the middle layer and 0.6 to 2.0 inches per hour in the lower layer (U.S. Department of Agriculture, 1984).

1.2.5 Spray Application Policies

The following environmental control criteria were established to limit the application rate of the liquid from Pond 207-B North (Rockwell, 1981b):

- o Annual application of NO_3 not to exceed 400 pounds per acre.
- o Monthly application of NO_3 not to exceed 80 pounds per acre.
- o Application must stop if vegetation shows visual degradation.
- o No runoff or erosion due to spraying.

TABLE 1-1

TYPES AND TYPICAL PROPERTIES OF THE UPPER FIVE FEET OF SOIL IN THE WEST SPRAY FIELD (U.S. Department of Agriculture, 1984)

Depth (in)	Soil Description	Unified Soil Classification	AASHTO Classification	-200 (%)	Liquid Limit (%)	Plasticity Index (%)
0-13	Very cobbly, sandy loam	GM,SM	A-1,A-2	10-30	15-25	NP-5
13-47	Very gravelly, clay Very gravelly, sandy clay Very gravelly, clayey loam	GC	A-2,A-6 A-7	25-40	35-60	20-50
47-60	Very gravelly, sandy, clayey loam	GC	A-2	15-30	25-35	10-20

NP = Non-plastic

Spray application was authorized and managed by the Environmental Management Group for each application event.

1.2.6 Spray Application Procedures

1.2.6.1 Operations

The west spray field, which operated from 1982 to 1985, was used when excess liquids accumulated in Ponds 207-B North or Center. When the storage capacity of one of the ponds was reached, the liquids contained were pumped to the spray field for spraying. The B-series solar ponds 207B North, Center, and South had all process waste removed in the late 1970s, as detailed in the Solar Pond Closure Plan of July 1, 1988. Since that time, the B-series solar ponds have not held process waste. The 207B-North and Center ponds had liquid inputs on a relatively constant basis due to the constant generation of treated sanitary wastewater which was placed in 207B-Center, and due to relatively constant generation of collected ground water north of the solar ponds which was placed in 207B-North. The ground water in this area was, and is, collected due to the elevated nitrates present in the water, and the need to prevent offsite migration of the water. These wastes were considered non-radioactive and non-hazardous and, therefore, amenable to spray irrigation.

Liquids from Pond 207-B North were primarily applied in Area 1. Preventing surface runoff was the limiting criteria for application of the liquids (Shirk, 1986). Generally, spraying from Pond 207-B North occurred in intervals of six to ten hours of daily application for periods of two to four days. The water present in Pond 207B North consisted of contaminated ground water collected by a french drain system and returned to Pond 207B North. This waste is typically characterized by high nitrate concentrations, trace levels of volatile organic compounds (VOCs), and elevated gross alpha, gross beta and uranium. A summary of characterization data is presented in Section 1.2.10.

Liquids from Pond 207-B Center were applied to all three application areas. Preventing surface runoff was also the limiting criteria for application of this liquid. Application periods for these liquids were similar to those for the 207-B North pond water (Shirk, 1986). The water present in Pond 207B-Center consisted of treated sanitary effluent from the Rocky Flats Plant sanitary wastewater treatment plant.

The specific locations of the initial portable irrigation lines and the area of application within the spray field covered during each application are generally in Area 1 where the fixed lines were subsequently located.

1.2.6.2 Application Rate

The total monthly volumes of liquids applied to the west spray field from Ponds 207-B North and Center are shown on Tables 1-2 and 1-3, respectively.

Total application rates for the spray field were between 250 and 450 gallons per minute. For the spray irrigation lines, these total rates convert to maximum surface application rates of between about 20 and 40 gallons per minute per acre. These application rates are based on an average application area of 2.7 acres along each of four irrigation lines and 0.7 acres for the impulse canon. The spray impulse cannon has a discharge of 125 gallons per minute for a surface application rate of about 175 gallons per minute per acre.

TABLE 1-2

APPLICATION OF LIQUID FROM
POND 207-B NORTH
TO THE WEST SPRAY FIELD

Date	Volume Applied (gallons)
4/82	522,000
6/82	760,000
10/82	244,000
Yearly Subtotal	1,526,000
1/83	555,000
6/83	865,000
7/83	1,112,000
11/83	367,000
Yearly Subtotal	2,899,000
3/84	231,000
4/84	864,000
5/84	216,000
7/84	169,000
10/84	929,000
Yearly Subtotal	2,409,000
3/85	132,000
7/85	1,266,000
10/85	781,000
Yearly Subtotal	2,179,000
TOTAL	9,013,000

TABLE 1-3

APPLICATION OF LIQUID FROM
POND 207-B CENTER
TO THE WEST SPRAY FIELD

Date	Volume Applied (gallons)
4/82	2,971,000
5/82	4,869,000
6/82	3,307,000
7/82	3,179,000
8/82	2,130,000
9/82	2,334,000
10/82	3,371,000
11/82	3,018,000
12/82	434,000
Yearly Subtotal	25,613,000
1/83	556,000
2/83	1,193,000
3/83	760,000
5/83	820,000
6/83	1,135,000
7/83	2,140,000
8/83	1,426,000
9/83	1,277,000
10/83	1,859,000
11/83	1,691,000
12/83	2,493,000
Yearly Subtotal	15,350,000
2/84	2,209,000
3/84	710,000
4/84	597,000
5/84	2,315,000
6/84	1,901,000
7/84	1,488,000
10/84	660,000
12/84	1,825,000
Yearly Subtotal	11,705,000

TABLE 1-3 (continued)

APPLICATION OF LIQUID FROM
POND 207-B CENTER
TO THE WEST SPRAY FIELD

Date	Volume Applied (gallons)
1/85	2,087,000
2/85	250,000
3/85	455,000
4/85	1,265,000
5/85	110,000
6/85	528,000
Yearly Subtotal	4,695,000
TOTAL	57,363,000

Based on the total volumes applied between April 1982 and October 1985 and the estimated areas of application of 8.4, 2.5 and 0.7 acres for Areas 1, 2 and 3, a total average application was estimated. The estimated total application is about 40 inches for liquids from Pond 207-B North applied in Area 1. The estimated total application is about 185 inches for Pond 207-B Center liquids, applied in Areas 1, 2 and 3. Since liquids from both ponds were applied in Area 1, the maximum total application was about 225 inches for all four years of operation.

1.2.6.3 Equipment and Labor Required

The equipment required to transfer the liquid from Ponds 207-B North and Center to the west spray field is described in Section 1.5. The spray field was operated by one person at a time, with no more than four or five operators over the period of spraying (Shirk, 1986).

1.2.7 Other Disposal Methods

Liquid to be applied to the west spray field was not disposed by any other method. The west spray field was used as a backup to dispose of excess water not processed by Ponds 207-B North and Center and Building 374.

1.2.8 Storage Facilities

No storage facilities existed at the west spray field. Ponds 207-B North and Center provide storage for the liquid applied to the west spray field. However, the liquid applied to the west spray field was not held in any other location. The solar evaporation ponds are covered under a separate closure plan (Rockwell, 1986b).

1.2.9 Pretreatment Facilities

No pretreatment was conducted on the liquids from either Pond 207-B North or Center prior to delivery to the west spray field. However, the 207B-Center liquid was sanitary wastewater effluent. The raw sanitary waste had been treated in the Rocky Flats Plant sanitary wastewater treatment plant prior to placement in 207B-Center.

1.2.10 Waste Characteristics

1.2.10.1 Introduction

The contents in Pond 207B North during operation of the West Spray Field generally consisted of liquid collected in the and french drain system located in the hillside north of the solar evaporation ponds (Figure 1-4). This system collects ground water and has historically controlled seepage from the solar ponds from entering North Walnut Creek. The liquid is pumped to Pond 207-B North from the low point of the interceptor system, the interceptor trench pump house.

The liquid contained in Pond 207-B Center during operation of the West Spray Field generally consisted of effluent from the Rocky Flats sanitary sewage treatment plant. However, some contents from Pond 207B-North had occasionally been transferred to Pond 207-B Center.

1.2.10.2 Characteristics

Liquids applied in the west spray field were derived from solar evaporation Ponds 207-B North and Center. The major constituent in the liquids from Pond 207-B North was nitrate. Elevated pH was characteristic of the liquids from Pond 207-B Center. Complete characterization of the liquids delivered to the spray field from 207B-North during the operating time period is not available, but analyses of the 207B-Center water from that period are available. During the period of 1984 to 1985, several indicator parameters were monitored on a weekly basis in the solar ponds (U.S. Department of Energy, 1985). Parameters monitored included pH, nitrates, gross alpha and gross beta. Two sets of metal analyses of Pond 207-B North and Center liquids were performed in October 1984 and April 1985. In addition, sampling of the liquids from Pond 207-B North and the Interceptor Trench Pump House (ITPH) were conducted in 1986, 1987 and 1988. A summary of the available characterization data is presented in Table 1-4.

A discussion of the results of the waste characterization is presented in Appendix 4, Section 4.1. The waste characterization summary concludes that nitrate and uranium are the only constituents of the applied solar pond waters that were consistently and significantly elevated relative to the proposed ground-water concentration limits. Therefore, these constituents should be the best indicators

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" Test Result Reference Number

ANALYTE	UNITS	POND 207-B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
pH		(1) 7 5 9 6 (7) 8 0 8 5	(1) 7 3 11 3 (7) 9 6 10 5	(11) 7 8 8.0 (13) 7 7 (15) 6 99 - 7 23	(8) 3 5 10 (9) 9 8
Nitrate as Nitrogen	(mg/l)	(1) 335 1,367 (7) 212 507	(1) ND - 15 6 (7) 346 4 1221	(13) 460 (14) 400 (15) 341 724	(8) 0 2 16 6 (9) <0 2
Total Disolved Solids	(mg/l)		-	(14) 2,784 2,868 (15) 2,360 4,555	(8) 340 630
Cyanide	(mg/l)		- -	(11) <0 05 (13) <0 01	(10) 0 016
RADIONUCLIDES (Units in pCi/l)					
Gross Alpha	(pCi/l)	(1) 13(50) 323(33) (3) 74(58) - 120(50) (7) 52(20) 200(80)	(1) 4(0) - 59(23) (7) 57(21) - 2,500(400)	(11) 100(40) 120(40) (13) 64(16) (14) 71(4) 84(22) (15) 10 8(13 3) 50 1(22 0)	(8) 0 - 35 (9) 34(4)
Gross Beta	(pCi/l)	(1) 5(25) 163(25) (3) 56(32) 100(92) (7) 67(3) - 200(80)	(1) 8(11) 73(0) (7) 72(16) 1,500(200)	(11) 75(25) 120(40) (13) 59(5) (14) 90(49) 115(5) (15) 47 4(14 2) 135(22 7)	(8) 0 212 (9) 65(27)
Pu, Plutonium 239	(pCi/l)	(3) ND	-- -	(11) 0 05(0 08) 0 16(0 10) (14) 0 0(0 55) 0 0(1 3) (15) 0 0(0 37) 0 84(0 44)	
Am, Americum 241	(pCi/l)	(3) ND	-- -	(11) 0 01(03) 0 02(0 05) (14) 0 0(2 3) - 0 0(8 5)	- -

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 1988

"( )" Test Result Reference Number

ANALYTE	UNITS	POND 207 B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
U, Uranium	(pCi/l)		-		
U, Uranium 233 + 234	(pCi/l)	(3) 50(2) 53(2)	--	(11) 62(2) 66(2) (15) 27 6(4 92) 122(4 16)	
U, Uranium 234	(pCi/l)		--	(13) 14 8(1 2) (14) 50(7) 58(7)	
U, Uranium 235	(pCi/l)			(13) 3 6(0 6) (14) 1 2(0 8) 1 4(1 0)	
U, Uranium 238	(pCi/l)	(3) 31(1) 33(1)	-	(11) 40(2) 44(2) (13) 9 9(1 0) (14) 31(5) - 36(5) (15) 15 2(3 68) 84 8(3 47)	
Tritium	(pCi/l)	(3) 1,200(300) 1,300(300)	--	(11) 2700(300) 3400(300) (13) 1,931(64) (14) 1,600(110) 2,200(110) (15) 2,480(304) 2,960(308)	
Total Radium	(pCi/l)			(13) <2	(8) <0 1 (9) <0 1
METALS (Units in ppm)					
Al, Aluminum	(mg/l)	(2) 0 16 (2) 1 (4) ND (5) < 0028 (6) < 003	(2) 0 15 (2) 2 0 (5) < 0032 (6) < 0035	(11) <0 2 (13) 0 087 (14) <0 029 (15) <0 2	(8) 0 32 (9) 0 32
Sb, Antimony	(mg/l)	(5) < 028 (6) < 03	(5) < 032 (6) < 035	(11) <0 06 (13) <0 06 (14) <0 06 (15) <0 060	(8) <0 05 (9) <0 05 (10) <0 005

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

ANALYTE	UNITS	POND 207-B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
As, Arsenic	(mg/l)	(4) ND (5) < 01 (6) < 01	(5) < 01 (6) < 01	(11) <0 01 (13) <0 01 (14) <0 01 (15) <0 01	(10) <0 005
Ba, Barium	(mg/l)	(4) ND - 0.220 (5) <1 0 (6) <1 0	(5) <1 0 (6) <1 0	(11) <0 2 (13) 0 171 (14) 0 1832 - 0 1878 (15) <0 2	(8) <0 5 (9) <0 5
Be, Beryllium	(mg/l)	(4) ND (5) < 05 (6) 0 06	(5) < 05 (6) < 05	(11) <0 005 (13) <0 004 (15) <0 005	(10) <0 005
Bi, Bismuth	(mg/l)	(5) < 014 (6) < 015	(5) < 016 (6) < 018		
B, Boron	(mg/l)	(2) 0 29 (2) 0 31 (5) 0 14 (6) 0 09	(2) 0 24 (2) 0 67 (5) 0 13 (6) 0 071		(8) <0 67 (9) 0 67
Cd, Cadmium	(mg/l)	(4) ND (5) < 01 (6) 0 01	(5) < 01 (6) 0 01	(11) <0 005 (13) 0 0007 (14) <0 005 (15) <0 005	(10) <0 005
Ca, Calicum	(mg/l)	(2) 20 0 (2) 290 (4) 176 - 198 (5) 96 0 (6) 180 0	(2) 2 9 (2) 45 0 (5) 95 0 (6) 66 0	(11) 308 319 (13) 242 255 (14) 247 250 (15) 240 400	(8) 0 1 0 6
Ce, Cerium	(mg/l)	(5) <2 8 (6) <3 0	(5) <3 2 (6) <3 5		
Cs, Cesium	(mg/l)	(2) ND (2) ND (5) < 28 (6) < 3	(2) ND (2) 0 041 (5) < 32 (6) 0 35	(14) <0 2	

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

ANALYTE	UNITS	POND 207 B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Co, Cobalt	(mg/l)	(4) ND (5) < 014 (6) < 015	(5) < 016 (6) < 018	(11) <0 02 (13) <0 02 (14) <0 022 (15) <0 05	(8) <0 01 (9) <0 01
Cr, Chromuim	(mg/l)	(4) ND (5) < 05 (6) < 05	(5) < 05 (6) < 05	(11) 0 007 0 009 (13) <0.01 (14) <0 01 (15) <0 01	(8) 0 05 (10) 0 025
Cu, Copper	(mg/l)	(2) ND (2) ND (4) ND (5) < 014 (6) < 015	(2) 0 016 (2) 0 037 (5) < 016 (6) < 018	(11) <0 005 (13) <0 008 (14) <0 0063 (15) <0 025	(8) <0 1 (10) <0 005
Ge, Germanium	(mg/l)	(5) < 014 (6) < 015	(5) < 016 (6) <.018		
Fe, Iron	(mg/l)	(2) 0 28 (2) 0 29 (4) ND (5) 0 057 (6) < 03	(2) 0 074 (2) 0 2 (5) 0 13 (6) < 035	(11) <0 02 (13) 0 101 (14) <0 0069 (15) <0 1	(8) 0 52 (9) 0 52
Pb, Lead	(mg/l)	(2) ND (2) 0.0035 (4) ND (5) < 0028 (6) < 003	(2) ND (2) 0.002 (5) <.0032 (6) < 0035	(11) <0 005 (13) <0 005 (14) <0 005 (15) <0 005	(10) <0 005
Li, Lithium	(mg/l)	(2) 0 37 (2) 3.5 (5) 1 7 (6) 6 0	(2) 0 052 (2) 0 41 (5) 2.9 (6) 3.5		
Mn, Manganese	(mg/l)	(2) ND (2) ND (4) ND - 0 015 (5) < 0028 (6) < 003	(2) 0.022 (2) 0 081 (5) <.0032 (6) < 0035	(11) 0 012 0 013 (13) 0 006 (14) 0 0057 0 0074 (15) <0 015	(8) <0 1 (9) 0 04

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 1988

"( )" Test Result Reference Number

ANALYTE	UNITS	POND 207 B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Mg, Magnesium	(mg/l)	(2) 87 0 (2) 120 0 (4) 66 4 - 72 6 (5) 88 0 (6) 80 0	(2) 3 9 (2) 13 0 (5) 86 0 (6) 91 0	(11) 76 8 77 4 (13) 64 2 66 6 (14) 64 2 - 65 9 (15) 65 97	(8) 5 0 (9) 5 0
Hg, Mercury	(mg/l)	(4) ND (5) < 002 (6) < 002	(5) < 002 (6) < 002	(11) 0 0004 0 0005 (13) <0 0002 (14) <0 0002 (15) <0 0002	(10) <0 0001
Mo, Molybdenum	(mg/l)	(2) ND (2) 0 0069 (5) < 0028 (6) 0 003	(2) 0 016 (2) 0 037 (5) 0 019 (6) 0 035	(14) <0 022	(8) <0 05 (9) <0 05
Ni, Nickel	(mg/l)	(2) ND (2) ND (4) ND - 0 050 (5) < 028 (6) < 03	(2) 0 015 (2) 0 016 (5) < 032 (6) < 035	(11) <0 02 (13) <0 024 (14) <0 037 (15) <0 040	(10) <0 02
Nb, Niobium	(mg/l)	(5) < 14 (6) < 15	(5) < 16 (6) < 18		
P, Phosphorous	(mg/l)	(2) ND (2) ND (5) < 14 (6) < 15	(2) 0 074 (2) 0 2 (5) < 16 (6) 0 18	-	(8) 0 8 (9) 0 80
K, Potassium	(mg/l)	(2) 82 0 (2) 120 (4) 56 1 62 7 (5) 89 0 (6) 64 0	(2) 30 0 (2) 36 0 (5) 98 0 (6) 110 0	(11) 71 5 73 7 (13) 64 9 66 9 (14) 64 - 65 (15) 38 - 101	(8) 2 42
Rb, Rubidium	(mg/l)	(5) < 28 (6) < 3	(5) < 32 (6) < 35	-	

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" Test Result Reference Number

ANALYTE	UNITS	POND 207 B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Se, Selinium	(mg/l)	(2) 0 01 (2) 0 02 (4) 0 009 (5) < 01 (6) 0 024	(2) ND (2) ND (5) < 01 (6) 0 019	(11) 0 011 0 012 (13) 0 0051 (14) <0 005 (15) <0 005 0 009	(10) <0 005
Si, Silicon	(mg/l)	(2) 2 1 (2) 5 6 (5) 2 1 (6) < 5	(2) 2 4 (2) 5 5 (5) 1 4 (6) 1 6	-	(8) 5 10
Ag, Silver	(mg/l)	(2) ND (2) 0 082 (4) ND (5) < 0028 (6) < 003	(2) 0 0016 (2) 0 015 (5) < 0032 (6) < 0035	(11) 0 010 0 012 (13) 0 008 (14) <0 0076 (15) 0 010 - 0 060	(10) <0 005
Na, Sodium	(mg/l)	(2) 370 0 (2) 620 0 (4) 363 - 451 (5) 820 (6) 770 0	(2) 67 0 (2) 250 0 (7) 800 0 (5) 650 0 (6)	(11) 451 462 (13) 397 406 (14) 378 383 (15) 300 520	(8) 104 200
Sr, Strontium	(mg/l)	(2) 1 2 (2) 3 5 (5) 0 14 (6) 0 21	(2) 0 28 (2) 0 52 (5) 0 16 (6) 0 14	(14) 1 99 2 04 (15) 2 2 3 6	
Ta, Tantalum	(mg/l)	(5) < 028 (6) < 03	(5) < 032 (6) < 035		
Te, Tellurium	(mg/l)	(5) < 28 (6) < 3	(5) < 32 (6) < 35		
Tl, Thallium	(mg/l)	(5) < 014 (6) < 015	(5) < 016 (6) < 018	(11) <0 01 (13) <0 01 (14) <0 01 (15) <0 01	(10) <0 005
Th, Thorium	(mg/l)	(5) < 028 (6) < 03	(5) < 032 (6) < 035		

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" Test Result Reference Number

ANALYTE	UNITS	POND 207 B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Sn, Tin	(mg/l)	(4) ND (5) < 028 (6) < 03	(5) < 032 (6) < 035	(11) <0 4 (13) <0 038	
Ti, Titanium	(mg/l)	(5) < 014 (6) < 015	(5) < 016 (6) < 018		(8) <0 1 (9) <0 1
W, Tungsten	(mg/l)	(5) <1 4 (6) <1 5	(5) <1 6 (6) <1 8		
U, Uranium	(mg/l)	(5) <1 4 (6) <1 5	(5) <1 6 (6) <1 8	--	
V, Vanadium	(mg/l)	(2) ND (2) ND (4) ND (5) < 028 (6) < 03	(2) ND (2) 0 0081 (5) < 032 (6) < 035	(11) <0 05 (13) 0 015 (14) <0 024 (15) <0 050	
Zn, Zinc	(mg/l)	(2) ND (2) ND (4) ND 0 022 (5) < 14 (6) < 15	(2) 0 041 (2) ND (5) < 16 (6) < 18	(11) 0 024 0 030 (13) 0 032 (14) 0 05 - 0 08 (15) 0 03 - 0 04	(8) 0 1 - 0 3 (10) 0 042
Zr, Zirconium	(mg/l)	(2) ND (2) ND (5) < 028 (6) < 03	(2) 0 0041 (2) ND (5) < 032 (6) < 035		
Phenols	(mg/l)	(4) 0 003 - 0 046	- -	(11) 0 01	(10) 0 004

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

ANALYTE	UNITS	POND 207 B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
VOLATILES (Units in ppb)					
Chloromethane	(ug/l)	(11) <10	-	(11) <10 (12) <1 (15) <10	(10) <10
Bromomethane	(ug/l)	(11) <10	---	(11) <10 (12) <1 (15) <10	(10) <10
Vinyl chloride	(ug/l)	(11) <10	----	(11) <10 (12) <1 (15) <10	(10) <10
Chloroethane	(ug/l)	(11) <10	--	(11) <10 (12) <1 (15) <10	(10) <10
Methylene chloride	(ug/l)	(11) 19 - 35	--	(11) 3 14 (12) <4 (15) 1 0	(10) <5
Acetone	(ug/l)	(11) <10	----	(11) <10 (12) <2 (15) <10	
Carbon disulfide	(ug/l)	(11) <5	- --	(11) <5 (12) <1 (15) <5	
Trichlorofluoromethane	(ug/l)	- --	---	(12) <1	(10) <5
1,1 Dichloroethene	(ug/l)	(11) <5	---	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 1988

"( )" Test Result Reference Number

ANALYTE	UNITS	POND 207 B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
1,1 Dichloroethane	(ug/l)	(11) <5	-	(11) <5 (12) <1 (15) <5	(10) <5
Total 1,2 Dichloroethene	(ug/l)	(11) <5		(11) <5 (12) <1 (14) <4 (15) <5	(10) <5
Chloroform	(ug/l)	(11) 3 6	--	(11) 3 6 (12) <1 1 4 (13) 2 (14) <4 (15) 2 0	(10) <5
1,2 Dichloroethane	(ug/l)	(11) <5	-- --	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5
2 Butanone	(ug/l)	(11) <10	----	(11) <10 (12) <1 (15) <10	
1,1,1 Trichloroethane	(ug/l)	(11) <5	----	(11) <5 (12) <1 - 4 8 (13) 9 (14) <4 (15) <5	(10) <5
Carbon tetrachloride	(ug/l)	(11) <5	----	(11) 6 7 (12) <1 - 2 1 (13) 8 (14) 6 (15) 1 0	(10) <5
Vinyl acetate	(ug/l)	(11) <10	- -	(11) <10 (15) <10	

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 1988

"( )" Test Result Reference Number

ANALYTE	UNITS	POND 207-B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Bromodichloromethane	(ug/l)	(11) <5	-	(11) <5 (12) <1 (15) <5	(10) <5
1,2 Dichloropropane	(ug/l)	(11) <5	-- -	(11) <5 (12) <1 (15) <5	(10) <5
c 1,3 Dichloropropene	(ug/l)	(11) <5	- --	(11) <5 (12) <1 (15) <5	(10) <5
Trichloroethene	(ug/l)	(11) <5	- -	(11) 7 8 (12) 2 4 3 7 (13) 6 (14) 8 (15) <5	(10) <5
Benzene	(ug/l)	(11) <5	-	(11) 1 (12) <1 (15) <5	(10) <5
Dibromochloromethane	(ug/l)	(11) <5	-	(11) <5 (12) <2 (15) <5	(10) <5
1,1,2 Trichloroethane	(ug/l)	(11) <5	-	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5
t 1,3 Dichloropropene	(ug/l)	(11) <5		(11) <5 (12) <1 (15) <5	(10) <5
2 Chloroethylvinyl ether	(ug/l)	(11) <10	-	(11) <10 (12) <2 (15) <10	(10) <5

TABLE 1 4
LIQUID CHARACTERIZATION SUMMARY 1984 1988

"( )" Test Result Reference Number

ANALYTE	UNITS	POND 207-B NORTH	POND 207 B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Bromoform	(ug/l)	(11) <5	- --	(11) <5 (12) <4 (15) <5	(10) <5
4 Methyl 2 Pentanone	(ug/l)	(11) <10	----	(11) <10 (12) <1 (15) <10	
2 Hexanone	(ug/l)	(11) <10	- --	(11) <10 (15) <10	
1,1,2,2 Tetrachloroethane	(ug/l)	(11) <5	- --	(11) <5 (12) <1 (15) <5	(10) <5
Tetrachloroethene	(ug/l)	(11) <5	--	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5
Toluene	(ug/l)	(11) <5	---	(11) <5 (12) <1 (15) <5	(10) <5
Chlorobenzene	(ug/l)	(11) <5	- --	(11) <5 (12) <1 (15) <5	(10) <5
Ethylbenzene	(ug/l)	(11) <5	-	(11) <5 (12) <1 (15) <5	(10) <5
Styrene	(ug/l)	(11) <5	-	(11) <5 (12) <1 (15) <5	
Total Xylenes	(ug/l)	(11) <5	--	(11) <5 (12) <1 (15) <5	

NOTES FOR TABLE 1-4

1. Summary of weekly sampling for Ponds 207B North and Center liquids, Appendix 3, Table 3-II.

2. Summary of two sets of metals analyses of Ponds 207B North and Center liquids, October 1984 and April 1985, Appendix 3, Table 3-III.

3. Summary of radiochemical analyses, April and May 1986, Appendix 4, Table 4-I.

4. Summary of metals and phenols testing, April and May, 1986, Appendix 3, Table 3-IV.

5. 207B Solar Pond North and Center quarterly metals analysis, August 14, 1987, Lab No. E87-3918, Appendix 4.

6. 207B Solar Pond North and Center quarterly metals analysis, November 30, 1987, Lab No. E87-4254, Appendix 4.

7. 207B Solar Pond weekly analysis results (liquids), October 1987 to June 1988.

8. Table 3-9, typical sewage effluent quality, Building 995 outfall, Rocky Flats Plant, from Draft of ASI Report on Water Management at RFP, August, 1988.

9. Analytical report from General Laboratory, 374 product water and 995 outfall, received 5-14-87, from draft of ASI report on Water Management at RFP, August, 1988.

10. Report of analysis from Accu-Labs Research, Inc., 374 product water and 995 effluent, 6-18-87, from draft of ASI report on Water Management at RFP, August, 1988.

11. Laboratory test results, Solar Ponds 207A and 207B North, Interceptor Trench Pump House, Buffer Zone, April and May, 1986; Appendix 4 of Solar Evaporation Ponds Closure Plan, July 1, 1988.

12. Resample of Interceptor Trench Pumphouse, Laboratory Test Results, Solar POnds 207A and 207B North, Interceptor Trench Pump House, Buffer Zone, April and

May, 1986; Appendix 4 of Solar Evaporation Ponds Closure Plan, July 1, 1988.

13. NEIC Ground-Water Monitoring Evaluation, U.S. Department of Energy, Rocky Flats Plant, July, 1988, EPA-330/2-88-051.

14. 1987 Interceptor Trench Pumphouse Water Data, Rocky Flats Plant, Golden, Colorado.

15. 1988 Surface Water Sampling Data, Roy F. Weston, Inc., Stockton Analytical Laboratory, September 1, 1988, I.D. SW88A084 and SW88A086.

of the soil (or ground water) contamination that may have resulted from application of water at the west spray field.

1.3 Maximum Extent of Operation

1.3.1 Maximum Total Area Used Over the Life of the Facility

The three areas, 1, 2 and 3, where application of liquids reportedly occurred are shown on Figure 1-3. The total area of likely application, including mobile units in Area 1, is about 38.8 acres (shaded area on Figure 1-3). Land potentially affected by surface runoff and/or wind blown wastes is approximately 66.3 acres adjacent to the areas of application. Therefore, a conservative estimate of the maximum area affected is the total area of the west spray field boundary or about 105.1 acres (Aerial Photograph, 1986 and Shirk, 1986).

1.3.2 Maximum Area Ever Sprayed at One Time

Based on site usage information, liquids from Pond 207-B Center were applied in Areas 1, 2 and 3 (Shirk, 1986). A conservative estimate of the maximum area of application is to assume operation in all three areas. The area of application at one time in Area 1 is estimated to have been a strip approximately 80 feet wide adjacent to the three irrigation lines in the area or about 8.4 acres. Application areas of Area 2 and 3 are 2.5 and 3.2 acres, respectively.

Therefore, the maximum area of application at one time is estimated to have been the combined areas in 1, 2 and 3 or 14.1 acres (Aerial Photograph, 1986 and Shirk, 1986).

The maximum area of application at one time for Pond 207-B North liquid is estimated to have been 8.4 acres or the area of application within Area 1 (Shirk, 1986).

1.3.3 Types of Waste Spread

Wastes applied in the west spray field were aqueous only. The characteristics of the waste applied to the spray field are discussed in Section 1.2.10.2 and Appendix 4, Section 4.1.

1.4 Maximum Waste Inventory

A closure plan must include "an estimate of the maximum inventory of wastes in storage and in treatment at any time during the life of the facility" [40 CFR 265.112(a)(2)]. "Inventory, in the case of land treatment facilities, includes all wastes in storage and pretreatment" (U.S. Environmental Protection Agency, 1981). The estimate of the maximum waste inventory should "always be high enough to ensure that if an inspector came onto the facility, the amount of wastes in storage as well as in pretreatment should not exceed the estimate in the plan, assuming normal operating conditions" (U.S. Environmental Protection Agency, 1981). The intent of 40 CFR Section 265.112(a)(2), as clarified by the U.S. Environmental Protection Agency, 1981, and as applicable to this facility is to provide an estimate of the wastes in storage and pretreatment from this date until closure.

Since the west spray field is no longer in operation, there are no wastes being stored in preparation for application to the west spray field. Pretreatment did not occur for the wastes applied. In the past, inventory for the spray field was held in the solar evaporation ponds prior to application. The solar ponds are covered under a separate closure plan (Rockwell, 1986b).

1.5 Description of Auxiliary Equipment

The auxiliary equipment consisted of a pump at the solar ponds, a delivery pipeline, the irrigation lines and an impulse cannon. The approximate locations of the equipment are shown on Figures 1-3 and 1-4.

The pump was a portable, engine driven centrifugal pump installed on the separator dike between Ponds 207-B North and Center. The pump and drive engine were mounted on a pneumatic-tired trailer. The engine was propane fueled with the fuel tank located at the toe of the dike for fuel truck access. The pump has since been removed for other use.

The pump intake was a flexible hose which could be connected to either valve stub from Ponds 207-B North or Center. The pump discharge was a rigid pipe connected to the delivery line.

The delivery pipeline was initially a six-inch diameter PVC pipe. The PVC pipe extended from the pump discharge at

Pond 207-B North beneath the patrol road, perimeter security zone and access road, approximately 900 feet in length. The pipeline then became a six-inch diameter light weight aluminum pipe. The aluminum pipe was in 40-foot sections with high-pressure connections. The pipeline was laid on the ground surface, except at the North Walnut Creek crossing where it was supported on about maximum three-foot high stanchions. The pipeline extended approximately 6,000 feet to the west spray field.

The delivery pipeline was connected to the irrigation header pipe with a six-inch diameter flexible hose. The header pipe was a six-inch diameter aluminum pipe similar to the delivery pipe, except at every other connection a four-inch diameter valved riser was installed. At the end of the header pipe was a plug and vacuum relief valve.

Initially, four-inch diameter portable spray irrigation lines approximately 1,300 feet in length were connected by flexible hose to the valve risers. The lines were attached to a ground anchor rod to prevent movement. The irrigation lines were equipped with fixed head impulse sprinklers for uniform application of the wastes. Subsequent to installation, the portable lines were damaged by wind and abandoned at the site with the exception of the single line presently located in Area 2. Subsequently, three fixed irrigation lines with lengths of between 1,350 and 1,570 feet were installed in Area 1 as shown on Figure 1-3. These lines consisted of fixed head impulse sprinklers for uniform application. A 125-gallon per minute spray impulse cannon with a flexible hose connection was placed in Area 3.

After operation of the spray field was terminated in October of 1985, the header pipe for Area 1 was relocated to its existing location (Figure 1-3). The fixed irrigation lines were moved to the new header pipe and additional irrigation lines added using excess from the old lines and new material. Three new lines were added to the original lines generally east of the previous area of application. The spray impulse cannon was also relocated onto the new header pipe. The existing irrigation configuration was never operated (Shirk, 1986).

The pipeline was drained after operation by a drain valve at the low point of the line just above the interceptor trench pump house. Liquids were drained into the pump house through a flexible hose.

1.6 Final Closure Plan Summary

1.6.1 Closure Objectives

This closure plan has been prepared to meet the performance standards of 6 CCR 1007-3, Section 265.11. The promulgated standards require a facility must be closed in a manner that:

- o minimizes the need for further maintenance, and
- o controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated rainfall, or waste decomposition products to the ground or surface water or to the atmosphere.

1.6.2 Closure Plan

The steps necessary to complete closure activities and comply with the post-closure ground-water monitoring requirements of 6 CCR 1007-3, Section 265.90 et seq. and the ground-water correction action requirements of 6 CCR 1007-3, Section 264 Subpart F are shown on the diagram in Figure 1-5.

Preliminary information regarding the site, total application amounts and wastes treated therein indicates soils should not be contaminated to the levels requiring additional treatment or remedial measures, therefore, no further closure activities are currently anticipated to be required as specified by 6 CCR 1007-3, Section 265.280. Additional studies are currently planned and intended to obtain data regarding the presence and level of constituents in the soils and ground water in the west spray field.

The decision to implement additional soil or ground-water treatment and selection of the treatment technologies to be used will depend on the types and degree of contamination found in the spray field and the results of additional studies to evaluate technology effectiveness, cost and duration of treatment required. The decision to conduct additional treatment will depend upon the cost effectiveness and the risk to public health during additional treatment. Potential treatment technologies, indicated on Figure 1-5, include:

- Tilling or scarifying the surficial soils,
- Addition of plant, microbial or bacterial nutrients,
- Spreading of admixtures in surficial soils,

- o Increasing or modifying vegetation on the field, and
- o Ground-water treatment.

Soils above the ground-water level may be completely or partially removed, if found contaminated. The decision to completely or partially remove these soils will depend on level of contamination, the associated costs and the risk to public health for alternative remedial actions. If all of these soils are removed, treated and disposed, no further closure activities are necessary.

If any soils contaminated to the degree they do not meet the closure performance standards in place, stabilization in place may be conducted. The decision to stabilize contaminants in place will depend upon the cost effectiveness and the risk to public health for alternative remedial actions. The stabilization technologies are presented on Figure 1-5 and include:

- o Injection of admixtures to the subsoils,
- o Passive or active air striping of the subsoils,
- o Addition of microbes and/or bacteria and nutrients to subsoil for biodegradation, and
- o Demonstration of natural geochemical immobilization or stabilization of contaminants.

Should alternative treatment be necessary, additional studies will be required to evaluate the technologies' potential effectiveness, costs and time required for implementation. In place stabilization may not require additional containment such as grading, capping or revegetation for closure. This type of closure, where wastes are stabilized in place, meets the objectives outlined in 6 CCR 1007-3, Section 265.280(a).

As part of closure in which contaminated soils remain in place, requirements for site grading, capping and revegetating will be evaluated. The decision to grade, cap or revegetate will depend on the potential of contaminant migration and the risk to public health associated with migration. Post-closure care and monitoring will be required for the land treatment site under 40 CFR 265.280. This type of closure, where wastes remain in place, meets 6 CCR 1007-3, Section 265.280(a).

The ground-water quality is being evaluated to determine if corrective action is required to meet 6 CCR 1007-3, Section 264 Subpart F. If necessary, the type of ground-water corrective action will be determined and implemented.

Compliance with the Resource Conservation and Recovery Act (RCRA), with respect to west spray field closure, will be achieved subsequent to meeting 6 CCR 1007-3, Section 265.280 and 6 CCR 1007-3 Section 264 Subpart F.

1.6.3 Closure Schedule

It is anticipated that closure with no wastes remaining in place will be possible The schedule of activities required to complete closure, based on no additional treatment or remedial actions being required, is provided in Figure 1-6. If closure with no wastes remaining cannot be implemented in accordance with the regulations, anticipated schedules for additional treatment, soil removal, contaminant stabilization and/or minimization of migration will be presented to CDH within 90 days of discovery.

1.6.4 Justification for Extension of Schedule

The regulations in 6 CCR 1007-3, Section 265.113(a) require:

> "Within 90 days after receiving the final volume of hazardous wastes, or 90 days after approval of the closure plan, if that is later, the owner or operator must treat, remove from the site, or dispose of on-site all hazardous wastes in accordance with the approved closure plan."

The intent of this regulation is to avoid causing serious environmental damage due to accumulating inventory over long periods of time. Additional regulations outlined in 6 CCR 1007-3, Section 265.113(b), require:

> "The owner or operator must complete closure activities in accordance with the approved closure plan and within 180 days after receiving the final volume of wastes or 180 days after approval of the closure plan, if that is later."

The activities for closure will take longer than schedules required by the referenced regulations. Characterization of the soil for evaluation of contamination will require 14 months before submittal to CDH/EPA for review. This is the result of DOE requirements for document review, 90-day laboratory turnaround time for sample analyses, and the need for adequate quality in data analysis and document preparation.

In the event that "clean" closure is not possible based on the characterization study, activities required to treat and dispose all wastes and to complete final closure at the west spray field will require further extension of the schedule. Closure activities cannot be defined prior to completion of site investigations and engineering studies. Schedules for closure activities and justifications for extension, as needed, will be presented at that time.

1.6.5 Protection of Human Health and the Environment

Pursuant to 6 CCR 1007-3, Section 265.113(a)(2), threats to human health and the environment during interim closure are prevented by the routine monitoring activities conducted at Rocky Flats and by restricted access to the facility. Specific details of the routine monitoring program are summarized in the "Annual Environmental Monitoring Report" (Rockwell, 1986b). This document is reviewed and updated on an annual basis. Brief discussions of the monitoring activities that are conducted and the security procedures at the plant are presented below.

The routine environmental monitoring program includes the sampling and analysis of airborne effluents, ambient air, surface and ground water, and soil. External penetrating gamma radiation exposures are also measured using thermoluminescent dosimeters. Samples are collected from on-site, boundary and off-site locations.

Particulate and tritium sampling of building exhaust systems is conducted continuously. For immediate detection of abnormal conditions, ventilation systems that service areas containing plutonium are equipped with Selective Alpha Air Monitors. These monitors trigger an alarm automatically if out-of-tolerance conditions are experienced. Particulate samples are collected from ambient air samplers operated continuously on site. The ambient air samples are analyzed for Total Long-Lived (TTL) Alpha activity or for plutonium activity. Twenty-three are located within and adjacent to the Rocky Flats exclusion area, 14 are located along or near the plant's perimeter and 14 are located in nearby communities.

The majority of the water used for plant process operations and sanitary purposes is treated and evaporated and/or reused for cooling tower makeup or steam plant use. the discharge of water off-site is minimized to the greatest extent possible. Water discharges from the Rocky Flats Plant are monitored for compliance with appropriate CDH standards and EPA National Pollutant Discharge Elimination System (NPDES) permit limitations. Surface runoff from precipitation is collected in surface water control ponds and discharged off site after monitoring. Routine water monitoring is conducted for two downstream reservoirs and for drinking water sources in nine communities. Ground-water monitoring was conducted during 1987 at approximately 160 ground-water sampling locations.

Soil samples are routinely collected on an annual basis from 40 sites located on radii from Rocky Flats at distances of 1.6 and 3.2 kilometers (one and two miles). The purpose of this soil sampling is to determine if there are any changes in plutonium concentrations in the soil around the plant.

When higher concentrations than usual are found in any of the routine monitoring activities or when out-of-compliance conditions are identified, the cause of the problem is investigated. If the present west spray field facility is found to be the cause of an out-of-compliance condition, then this closure plan will be revised within 90 days.

Access to the west spray field is limited by:

- o a three-strand barbed wire cattle fence surrounding the facility (Figure 1) posted to identify the land as a government reservation/ restricted area,
- o guards patrolling the controlled area 24 hours per day, and

- o surveillance by security cameras 24 hours per day.

The existing fences and gates are operated and maintained by the U.S. Department of Energy.

The monitoring and security measures outlined above are designed to protect human health and the environment from threats posed by the plant as a whole. In addition, they protect human health and the environment from threats posed by the west spray field.

1.6.6 Administration of Closure Plan

The closure plan for the west spray field will be kept at Rocky Flats Area Office, Building 115, U.S. Department of Energy. The person responsible for storing and updating this copy of the closure plan is:

Mr. Albert E. Whiteman
Area Manager

His address and phone number are:

U.S. Department of Energy
Rocky Flats Plant
P.O. Box 928
Golden, Colorado 80402
Phone: (303) 966-2025

Mr. Whiteman is also responsible for updating all other copies of the closure plan held off-site by sending additions or revisions by registered mail.

1.6.7 Closure Cost Estimates and Financial Assurance

State and Federal governments are exempt from the financial requirements imposed by Subpart H of 40 CFR [Section 265.140(c)]. Because the Rocky Flats Plant is a federally-owned facility, no cost estimates or financial assurance documentation are required. However, cost estimates are presented below for soil sampling, analytical costs, characterization report preparation, and closure certification. This estimate assumes "clean" closure.

Soil Sampling	$30,000
Analytical Costs	60,000
Report Preparation	25,000
Closure Certification	5,000
Total	$120,000

The estimates are provided for planning, budgeting and informational purposes. These estimates can in no way be considered binding.

2.0 INVENTORY DISPOSAL

2.1 Maximum Waste Inventory

Since the west spray field is no longer in operation, there are currently no wastes being stored in preparation for application to the west spray field. Pretreatment of wastes did not occur during operation. Therefore, pretreatment requirements, landspreading procedures or other disposal methods for inventory disposal are not applicable.

2.2 Schedule

There is no inventory remaining to be applied to the west spray field. Therefore, inventory disposal is complete at present.

3.0 MATERIAL IN TREATMENT

3.1 Maximum Extent of Operation

3.1.1 Maximum Total Area Used Over the Life of the Facility

As discussed in Section 1.3.1, the maximum area used is conservatively estimated to be about 105.1 acres or the entire area of the west spray field.

3.1.2 Maximum Area Ever Sprayed at One Time

As discussed in Section 1.3.2, the maximum area utilized at one time is conservatively estimated to be about 11.6 acres. This area included areas of direct application in Area 1 and the total area of Areas 2 and 3.

3.1.3 Types of Waste Applied

The liquids applied to the west spray field were from Ponds 207-B North and Center. The characteristics of the liquids applied to the west spray field are presented in Section 1.2.10.

3.2 Procedures for Materials in Treatment

Treatment which occurred in the west spray field included natural soil buffering of waste pH and utilization of the nitrates by native vegetation. It is anticipated that complete waste treatment has occurred at the site.

The types and extent of remaining wastes in treatment, if any, will be determined following the additional soil sampling and analyses and engineering studies. The treatment procedures required for the wastes in treatment, if necessary, will be determined subsequent to completing the proposed studies.

3.3 Schedule for Decomposition of Materials in Treatment

Decomposition or decay of wastes in treatment, if any, may occur. The schedule for decomposition of the materials will be estimated subsequent to completing the ongoing and additional studies. The schedule will be based on the level, type and decomposition or decay mechanism of the wastes found. It is anticipated that no wastes remain in treatment, therefore, decomposition would be complete at present.

4.0 SOIL TESTING AND REMOVAL OF CONTAMINATED SOIL

4.1 Soil Testing Performed to Date

Preliminary soil testing to evaluate whether the soils in the West Spray Field are contaminated and, if so, the level and extent of soil contamination has been conducted. Soil samples were collected during 1986 and 1988 to characterize the soil chemistry in the West Spray Field. The results of the preliminary soil characterizations performed to date are presented in Appendix 4, Section 4.2.

In 1986, field investigations included soil samples to a depth of one foot from a plot in the West Spray Field (Appendix 4, Figure 4-1). In 1988, the sampling program consisted of digging 12 test pits with a backhoe and collecting three soil samples for chemical analyses from each location at varying depths.

The preliminary conclusions may indicate that nitrate and volatile organic compounds are above estimated background concentrations in the West Spray Field soils. Levels of uranium, plutonium, and other radionuclides were found at levels typical of known or assumed background levels for the area. However, background soil and ground water at the Rocky Flats Plant in general, as well as the West Spray Field in particular, require additional characterization before the above statement can be adequately supported. A comprehensive plan for background characterization is under preparation. This plan will be implemented upon approval by CDH/EPA, and will yield data to conclusively determine whether or not the West Spray Field soils are contaminated. This plan will be submitted to CDH/EPA during calendar year 1988.

The soil sampling conducted to date in the West Spray Field provides a general idea of the types and levels of contamination which may be present in the West Spray Field soils. However, the information collected to date is not definitive enough to reach final conclusions because the background soil samples obtained in 1986 were taken to a maximum depth of one foot.

- Low levels of volatile organic compounds identified in the previous sampling are probably the artifacts of the sampling and laboratory testing considering the analyses of the applied liquids. However, quantitatively removing the volatiles based on the available data was not possible.

- The 1986 sampling plot was not in an area of direct spray application. At the time of sampling, it was believed this area received application from the spray impulse canon in the West Spray Field. Additional information subsequent to sampling and testing indicated the sample area was only affected by surface runoff, and perhaps windblown spray from application in Area 1.

4.2 Additional Soil Testing

Additional soil testing is necessary to complete the soil characterization in the West Spray Field. The results of the testing performed to date have been used to evaluate the scope of additional studies. The soil sampling plan for the additional studies in the West Spray Field is presented in Appendix 2.

The intent of the additional soil testing described in Appendix 2 is to identify areas affected by liquid waste application and identify the affects of waste application on the soils. Within the West Spray Field, five areas have been identified for soil sampling. These areas are:

- o direct application Area 1;
- o direct application Area 2;
- o direct application Area 3; and
- o the areas adjacent to direct application areas which may have been subjected to runoff and over spray.

These sampling areas are shown on Figure 2-1 of the Soil Characterization Plan in Appendix 2.

Soil samples will be obtained in the four areas as follows:

Sample Area	No. of Holes	No. of Samples
Area 1	17	51
Area 2	7	21
Area 3	8	24
Runoff and Windspray Affected Area	12	36
Total	44	132

Each sampling location will be sampled at a minimum of three vertical depths. The samples will be distributed in the vertical by obtaining one sample in each of the three major soil horizons described by the Soil Conservation Service mapping (Section 1.2.4) and identified during the 1988 field work. Samples will be obtained from each soil horizon identified during field work to determine if the varying soil characteristics have accounted for different interactions with contaminants present in the applied waste.

Types of Soil Tests: Soil samples will be obtained and tested in the laboratory for the following potential contaminants:

- Nitrates
- Percent Solids
- Volatile Solids
- Lead
- Mercury
- Plutonium 239
- Americium 241
- Uranium 233
- Uranium 234
- Uranium 238
- Tritium
- Total Organic Carbon
- Hazardous Substance List (HSL) Volatiles
  - Chloromethane
  - Bromomethane
  - Vinyl Chloride
  - Chloroethane
  - Methylene Chloride
  - Acetone
  - Carbon Disulfide
  - 1,1-Dichloroethene
  - 1,1-Dichloroethane
  - trans-1,2-Dichloroethene
  - Chloroform
  - 1,2-Dichloroethane
  - 2-Butanone
  - 1,1,1-Trichloroethane
  - Carbon Tetrachloride
  - Vinyl Acetate
  - Bromodichloromethane
  - 1,1,2,2-Tetrachloroethane
  - 1,2-Dichloropropane
  - trans-1,3-Dichloropropene
  - Trichloroethene
  - Dibromochloromethane
  - 1,1,2-Trichloroethane
  - Benzene
  - cis-1,3-Dichloropropene
  - 2-Chloroethyl Vinyl Ether
  - Bromoform
  - 2-Hexanone

4-Methyl-2-pentanone
Tetrachloroethene
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

4.3 Indicator Parameters and Closure Performance Standards

Based on the preliminary soil testing conducted to date, it is possible to establish a tentative set of indicator parameters and proposed closure performance standards for remedial actions in the West Spray Field. However, the data obtained during the final soil sampling may necessitate a change in the indicator parameters and the closure performance standards.

4.3.1 Indicator Parameters

Three groups of contaminants have been chosen for the west spray field. They are: nitrates, uranium and transuranics. These groups were chosen based on known elevated concentrations in the spray application water and data results from soil sampling to date in the west spray field.

Nitrates

Low-level radioactive wastes with high nitrate concentrations have been one of the forms of waste present in the solar ponds which contributed to ground water intercepted by the solar pond french drain system and sent to the west spray field. The drinking water standard for nitrates is 10 mg/l.

Uranium

Uranium is the only radionuclide (excluding the transuranic elements, plutonium and americium) that was considered representative of the spray application water. Uranium -233, -234 and -238 were chosen as indicator parameters.

Transuranics

The only transuranic used on site is plutonium. However, americium is a daughter product of plutonium, and can be found at the Rocky Flats Plant due to ingrowth.

4.3.2 Closure Performance Standards

Closure performance standards for potentially contaminated soils in the West Spray Field are set at two levels. The first level are standards below which no further action at the West Spray Field for soil contamination is indicated. The proposed no action levels for the indicator parameters are:

- Nitrates - less than 100 parts per million (ppm)
- Uranium - 32 pCi/g
- Plutonium - 0.9 pCi/g

These levels define the upper limit for no closure action. They are based on the Safe Drinking Water Act (SDWA), and state and federal guidelines. Nitrates are limited to ten times the SDWA. Since the SDWA applies to water, an elevated concentration is acceptable in the soil due to adsorption and transport partitioning. Ten times the SDWA is a conservative limit for protection of human health and the environment.

Uranium is limited to 32 pCi/g, or possibly as high as 320 pCi/g based on the method of fractions. The International Committee of Radiological Protection presents an acceptable standard of 100 millirems (mrem) of effective dose equivalent per year of exposure for long-term exposure for radionuclides from man-made sources (ICRP, 1977). The National Council on Radiological Protection (NCRP) has published soil guides for uranium, radium and lead-210 based on a dose rate of 500 mrem/year. Adjusting these guides to reflect the 100 mrem/year effective dose equivalent from ICRP (reducing each guide by a factor of five), results in adjusted guides of 320 pCi of uranium per gram of soil, 8 pCi of radium per gram of soil, and 3 pCi of lead-210 per gram of soil (NCRP, 1984). Since all of these materials are found in soil, the sum of the fractions (the observed concentration divided by the concentration limit) must not exceed unity (one). The sum of fractions technique is used by the Nuclear Regulatory Commission (NRC), U.S. DOE, and Colorado regulations when addressing mixtures. If any fraction is less than ten percent, the material is considered non-existent for the purposes of the sum of fractions calculation. Based on the above guides, preliminary analyses will be for uranium only. If the uranium concentration exceeds ten percent of the guide (32 pCi/gm), the radium and lead-210 concentrations in the soil sample will be determined. If the sum of the fractions is found to exceed unity, and the activity at the unit is significantly greater than the background activity for these compounds, soil removal will be used to reduce the sum of fractions to unity or less.

Plutonium is limited to 0.9 pCi/g (Colorado Department of Health, 1973). Below this concentration, no action is required.

Soil contamination above these levels would indicate some additional action following the logic on Figure 1-5 as indicated. Until the final soil sampling and soil background characterization is completed, it is not possible to define the type of remedial action which might be undertaken. Potential methods of treatment or disposal are discussed in Section 4.4.

The second level are standards above which soil removal is required. A closure performance standard of 20 picocuries per gram can be established for soil contaminated with combined plutonium and americium. Above this level, soil removal will be implemented.

Proposed recommendations by EPA are intended to provide long-term radiation protection for all exposed persons in a "critical segment of the general population" and specify that both the individual and collection radiation doses should be "as-low-as-reasonably-achievable (ALARA)." These interim recommendations present a soil screening level of

0.2 microcuries of transuranics per square meter in the upper 1 cm of soil. This represents a combined inhalation and ingestion incremental cancer risk of 1×10^{-6}. At activity levels greater than this, additional evaluation is recommended to determine the actual dose rates to exposed persons (U.S. Environmental Protection Agency, 1986). Assuming a soil density of 1 gm/cm^3, this activity level translates to 20 picocuries per gram (pCi/g) of soil.

Combined Pu and Am were selected for use as indicator parameter for soil removal with an acceptable combined level of 20 pCi/g (assuming 1 g/cm^3 soil density). Detectable levels of Pu and Am below this concentration level will be covered with a multi-layered cap or optionally removed. Soil with concentrations above this level will be removed and disposed at an approved facility. Similar wastes from the Rocky Flats Plant have been sent to the Nevada Test Site (NTS).

4.4 Method of Treatment or Disposal

4.4.1 On-site Treatment or Disposal

The on-site methods to treat or dispose the materials to be removed, if necessary, will be determined following completion of the additional soil sampling and analyses to be performed.

It is anticipated based on the characteristics of the wastes applied to the spray field that remaining wastes, if any, can be treated or stabilized at the site. As summarized on Figure 1-5, treatment could include:

- Tilling or scarifying the surficial soils,
- Addition of plant, microbes or bacterial nutrients,
- Spread of admixtures in surficial soils, and
- Increasing or modifying vegetation on the field.
- Ground-water treatment.

Stabilization on-site could include:

- Injection of admixtures to the subsoils,
- Passive or active air-striping of the subsoils,
- Introduction of microbes or bacteria and nutrients to the subsoils for biodegradation, and

- o Natural geochemical immobilization or stabilization.

4.4.2 Off-site Treatment or Disposal

It is anticipated that off-site measures will not be required for closure.

5.0 FACILITY DECONTAMINATION

5.1 Auxiliary Equipment

5.1.1 Identification of Auxiliary Equipment

The equipment used at the west spray field is described in general in Section 1.5. The auxiliary equipment present which may have conveyed waste liquids include:

Pump Unit:

- Industrial engine driven centrifugal pump and auxiliary equipment,
- Vacuum relief and drain valves and flexible drain line,
- Intake and discharge lines and couplings,

Delivery Pipeline:

- 900 feet of six-inch diameter PVC pipe (20-foot sections),
- 6,000 feet of six-inch diameter aluminum pipe (40-foot sections) and couplings,
- Drain valve and flexible drain line,

Irrigation Pipeline and System:

- 20 feet of six-inch diameter flexible hose and couplings,

- 3,000 feet of six-inch diameter aluminum pipe (40-foot sections) and couplings,
- 50 four-inch valved risers,
- End plug and vacuum relief valve,
- 2,600 feet, four-inch diameter aluminum, side-roll portable sprinkler irrigation pipe and impulse sprinkler heads,
- Two four-wheel movers with gasoline engine drive for irrigation lines,
- 20 feet of flexible hose and couplings,
- 6,500 feet of four-inch diameter aluminum irrigation pipe with impulse sprinkler heads,
- 100 feet of four-inch diameter flexible hose,
- 125 gallons per minute spray impulse cannon.

Numbers and quantities presented are estimated based on information available (Aerial Photograph, 1986, Rockwell, 1981a and 1981c, and Shirk, 1986).

5.1.2 Decontamination Procedures

In accordance with 6 CCR 1007-3, Sections 256.112(b)(4) and 265.114, a detailed description is required of the steps needed to remove and dispose, or decontaminate, all hazardous waste residues and contaminated containment system components and equipment.

Since the wastes applied at the West Spray Field were most characterized by elevated nitrates and trace VOC concentrations, residual contamination of auxiliary equipment is not anticipated. If the West Spray Field soils are found to be currently unimpacted by hazardous or radioactive wastes, all equipment used in the spraying operations that has not been removed will be considered decontaminated by inference. The engine driven pump and most of the six-inch PVC and aluminum delivery pipe have been removed for other use and are not subject to the decontamination procedures in this closure plan.

If the site does not meet the closure performance standard, and closure activities are required, construction equipment that may be contaminated by contact with the soil will also be decontaminated. All construction equipment involved with removing contaminated soils, lines and tanks will be scraped or brushed to remove chunks of soil or debris whenever the equipment leaves the excavation area. The areas used for scraping or brushing will be raked and/or swept to collect all removed chunks. The collected material will be handled as necessary based upon its radioactive and hazardous characteristics.

5.1.3 Evaluating Radioactive Contamination

All auxiliary equipment that has not been removed will be surveyed for radioactive contamination as a part of closure. It is currently anticipated that all such equipment will be well below regulatory or guidance levels of radioactive contamination given below.

5.1.3.1 Surveying for Alpha

The exposed area of the item will be surveyed for removable alpha contamination by smearing the item with a 5.5-centimeter (cm) Reeve-Angel filter paper and counting the smear in a scintillation-type smear counter instrument. To be considered "clean," the item must have removable alpha contamination less than 20 disintegrations per minute (dpm) per 100 square centimeters (cm^2). To facilitate surveys of larger surfaces, an area of one square meter will be smeared. For these large surfaces, the total activity must be less than 50 dpm to be considered "clean."

The exposed are of the item will also be surveyed for non-removable or fixed contamination using the air proportionaltype alpha survey instrument. The direct count must be less than 250 counts per minute (cpm) to be considered "clean."

If the removable alpha contamination is greater than 20 dpm/100 square centimeters, or the fixed contamination is greater than 250 cpm, the item will be broken down, packaged and shipped off site for disposal at a facility approved for disposal of radioactive wastes.

5.1.3.2 Surveying for Beta-Gamma

The exposed areas of the item will be surveyed for removable beta-gamma contamination by smearing the component with a 5.5-cm Reeve-Angel filter paper and counting the smear with a Ludlum Model 31 instrument. To be "clean," the item must have removable beta-gamma contamination less than 200 cpm/100 square centimeters, provided the background count does not exceed 100 cpm. For larger surfaces, an area of one square meter will be smeared. For these larger surfaces, the total activity must be less than 400 cpm, provided the included background count does not exceed 100 cpm.

The exposed areas of the item will also be surveyed for fixed beta-gamma contamination using a Ludlum Model 31, Geiger-Mueller type instrument. The instrument probe will be placed close to and moved slowly over the item and the count rate reading noted. The reading must be less than 600 cpm to be considered "clean," provided the background count does not exceed 100 cpm.

To be considered "clean," the combined total of removable and fixed beta-gamma contamination must be less than 60 cpm, provided the removable contamination is less than 200 cpm/100 square centimeters and the background count does not exceed 100 cpm.

If the background count exceeds 100 cpm, the count must be performed in a different area or sufficient shielding must be provided so that background level is not greater than 100 cpm.

5.1.4 Decontamination Facility

A decontamination facility is not currently anticipated to be necessary to complete the West Spray Field closure.

6.0 WASTE CONTAINMENT SYSTEM

6.1 Introduction

The west spray field may be closed with wastes remaining in place. Owners or operators of land treatment facilities, as required in 6 CCR 1007-3, Section 265.280(a), must address the following objectives regarding waste containment and indicate how they will be achieved.

- Controlling migration of hazardous waste and hazardous waste constituents from the treated area into the ground water.
- Controlling the release of contaminated run-off from the facility into surface water.
- Controlling the release of airborne particulate contaminants caused by wind erosion.

This section discusses methods of containment, presented on Figure 1-5, that may be used individually or in combination to meet the above mentioned objectives, if waste containment is required. These components are:

- Grading, including constructing drainage and diversion systems,
- Capping
- Vegetating

6.2 Area Requiring Containment

It is anticipated that no area of the West Spray Field will require containment. The need for containment will be reevaluated subsequent to completion of the additional sampling and analyses and engineering studies.

6.3 Characteristics of Containment System

6.3.1 Grading

6.3.1.1 General

It is anticipated that no area will require grading or containment. The grading requirement will be reevaluated upon completion of the additional soil sampling and analyses and engineering studies.

6.3.1.2 Constructing Drainage and Diversion Systems

It is currently believed that surface drainage and diversion systems to provide surface runon and runoff control at the West Spray Field, are not necessary. The need will be reevaluated subsequent to completing the additional sampling and analyses and engineering studies.

6.3.2 Capping

It is currently believed that a cap at the West Spray Field will not be necessary. The need for a cap will be reevaluated after completion of additional site characterization activities.

7.0 MONITORING OPERATIONS

Ground-water contamination at the Rocky Flats Plant has been the subject of ongoing investigations being performed pursuant to the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and the U.S. DOE Comprehensive Environmental Response Program (CERP).

An assessment of the ground-water contamination resulting from the west spray field is presented as part of the hydrogeological site characterization presented in Appendix 4.

Interim status and post-closure monitoring of ground water is discussed in Section E of the Post-Closure Care Permit.

8.0 FOOD CHAIN CROPS

40 CFR 265.276 requires:

> "An owner or operator of a hazardous waste land treatment facility on which food chain crops are being grown, or have been grown and will be grown in the future, must notify the Regional Administrator within 60 days after the effective date of this part."

Food chain crops are not grown and will not be grown at the west spray field.

9.0 SITE SECURITY

The existing security measures at the Rocky Flats plant include:

- a three-strand barbed wire cattle fence surrounding the facility (Figure 1) posted to identify the land as a government reservation/restricted area (U.S. Department of Energy, 1985), where the west spray field is located,
- a fence surrounding and guards posted 24 hours per day at two gates to the controlled area of the facility (Figure 1), and
- surveillance by security cameras 24 hours per day.

The existing security measures are sufficient to meet the requirements of 6 CCR 1007-3, Section 265.14.

The existing fences and gates are operated and maintained by the U.S. Department of Energy. Maintenance requirements will be performed by the U.S. Department of Energy, regardless of the activities at the west spray field.

10.0 CLOSURE CERTIFICATION

10.1 Certification Requirements

Closure certification requirements are outlined in 6 CCR 1007-3, Section 265.115 and 40 CFR 265.115:

> "Within 60 days of completion of closure of each hazardous waste surface impoundment, waste pile, land treatment, and landfill unit, and within 60 days of completion of final closure, the owner or operator must submit to the Department of Health/Regional Administrator by registered mail, a certification that the hazardous waste management unit or facility, as applicable, has been closed in accordance with the specifications in the approved closure plan. The certification must be signed by the owner or operator and by an independent registered professional engineer."

Certification by an independent registered professional engineer does not guarantee the adequacy of the closure procedures and does not necessarily involve detailed testing and analyses. It implies that, based on periodic facility inspections, closure has been completed in accordance with the specifications in the approved closure plan (U.S. Environmental Protection Agency, 1981).

10.2 Activities Requiring Inspections by a Registered Professional Engineer

The activities requiring inspections by an independent registered professional engineer cannot be finalized until the activities necessary for closure have been defined. The closure plan will be completed following completion of additional soil sampling and analyses and engineering studies.

The types of activities requiring inspections could include:

- performing additional treatment,
- removing all or portions of the contaminated soil,
- implementing stabilization technology,
- constructing containment systems in the west spray field,
- facility decontamination, and
- equipment decontamination or disposal.

10.3 Anticipated Schedule of Inspections by a Registered Professional Engineer

An independent registered professional engineer will periodically review the closure operations, when finalized, in order that a final certification of closure can be developed which states that the closure has been carried out according to the plan. The engineer will observe construction activities and be present during performance and completion of key closure activities. The engineer will periodically obtain and review the results of chemical testing which provide a record of the progress and effectiveness of the implemented closure plan.

The independent engineer and the owner will, at the end of closure, inspect the site and certify that the closure plan was carried out as described. Prior to final certification, deficiencies noted by the engineer will be corrected. When deficiencies have been corrected, the engineer will issue a written report to the regulatory agencies certifying that the facility has been closed according to this closure document.

REFERENCES

Aerial Photograph:

1986: Scharf & Associates, Flight No. 153.65, Photo No. 75005PB-1-1 to 75005PB-9-16, 5/21/86

Colorado Department of Health, 1973: Colorado Department of health, May 1, 1973, Roy L. Cleere, Executive Director, Notice of Publication of Amendment to Rules and Regulations Pertaining to Radiation Control.

Dow, 1975: Dow Chemical Company, April 1975, "Annual Environmental Monitoring Report, Rocky Flats Plant, January-December 1974," RFP-ENV-74.

ICRP, 1977: International Committee of Radiological Protection, January 17, 1977, ICRP Report Number 26, Published by Pergamon Press, New York.

NCRP, 1984: National Council on Radiological Protection, 1984, "Exposure to Uranium Series with Particular Emphasis on Radon and its Daughters," NCRP Report Number 77.

Rockwell, 1981a: Rockwell International, January 30, 1981, "Nitrate Waste Irrigation System, General Layout and Schematic Diagram," Drawing Nos. 28219-DO1 and -DO2.

Rockwell, 1981b: Rockwell International, February 1981, "Design Criteria for Portable Irrigation System, Rocky Flats Plant, Golden, Colorado, Volume 2," FE-924(8).

Rockwell, 1981c: Rockwell International, March 27, 1981, "Portable Irrigation System, Physical Layout and Schematic Arrangement," Drawing Nos. 28219-010 and -011.

Rockwell, 1986a: Rockwell International, July 21, 1986, "Draft Work Plan, Geological and Hydrological Site Characterization," Rocky Flats Plant, unnumbered report.

Rockwell, 1986b: Rockwell International, August 29, 1986, "Closure Plan, Solar Evaporation Ponds, U.S. Department of Energy, Rocky Flats Plant."

Setlock, 1985: Setlock, G.H. an Barker, C.J., March 1985, "Annual Environmental Monitoring Report, U.S. Department of Energy, Rocky Flats Plant, January through December 1984," Rockwell International, RFP-ENV-84.

Setlock, 1986: Setlock, G.H. and Barr, D.L., April 1986, "Annual Environmental Monitoring Report, U.S. Department of Energy, Rocky Flats Plant, January through December 1985," Rockwell International, RFP-ENV-85.

Shirk, 1986: Shirk, K., September 15, 1986, personal communication.

U.S. Department of Agriculture, 1984: U.S. Department of Agriculture, 1984, "Soil Survey of Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties," unnumbered report.

U.S. Department of Energy, 1985: U.S. Department of Energy, November 1985, "Resource Conservation and Recovery Act, Part B Permit Application, Radioactive Mixed Waste, Volumes 1 and 2," COD078343407.

U.S. Department of Energy, 1986a: U.S. Department of Energy, Albuquerque Operations Office, Environment, Safety and Health Division, Environmental Programs Branch, April 1986, "Comprehensive Environmental Assessment and Response Program, Phase 1: Installation Assessment, Rocky Flats Plant," Los Alamos National Laboratory.

U.S. Department of Energy, 1986b: U.S. Department of Energy, July 31, 1986, "Compliance Agreement," Rocky Flats Plant, agreement with the U.S. Environmental Protection Agency and the State of Colorado.

U.S. Department of Energy, 1987a: U.S. Department of Energy, December 15, 1987, "RCRA Part B Operating Permit Application for U.S. DOE-Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes," CO7890010526, Revision No. 1.

U.S. Department of Energy, 1986c: U.S. Department of Energy, March 11, 1986, "Annual Site Environmental Reports for Calendar Year 1985."

U.S. Environmental Protection Agency, 1981: U.S. Environmental Protection Agency, 1981, Reprinted 1984, with Addendum, "Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities under RCRA, Subtitle C, Section 3004, Closure and Postclosure-Interim Status Standards [40 CFR 265, Subpart (G)]," Report SW-912.

U.S. Environmental Protection Agency, 1986: U.S. Environmental Protection Agency, November 12, 1986, "Interim Guidance: Dose Limits for Persons Exposed to Transuranium Elements in the General Environment.

Weston, 1986a: Roy F. Weston, Inc., February 28, 1986, "Sampling and Analyses Plan, U.S. Department of Energy, Rocky Flats Plant, Solar Pond 207A," unnumbered report.

Weston, 1986b: Roy F. Weston, Inc., February 28, 1986, "Sampling and Analyses Plan, U.S. Department of Energy, Rocky Flats Plant, Solar Pond 207-B North, Interceptor Trench Pump House, West Spray Field," unnumbered report.

Weston, 1986c: R.F. Weston, Inc., Laboratory Test Results, Solar Ponds 207-A and -B North, Hydrologic Test Wells, Buffer Zone, West Spray Field and Interceptor Trench Pump House.

Woodward-Clevenger, 1974: Woodward-Clevenger & Associates, Inc., January 17, 1974, "Geotechnical Services, Proposed and Existing Landfills, Dow Chemical Rocky Flats Plant, Near Golden, Colorado," Job No. 17536-350.

APPENDIX 1

CEARP PHASE 2: INSTALLATION GENERIC MONITORING PLAN (IGMP); SAMPLING PLAN

DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
ENVIRONMENT, SAFETY AND HEALTH DIVISION
ENVIRONMENTAL PROGRAMS BRANCH

COMPREHENSIVE ENVIRONMENTAL ASSESSMENT AND RESPONSE PROGRAM

PHASE 2:
ROCKY FLATS PLANT
INSTALLATION GENERIC MONITORING PLAN
(Comprehensive Source and Plume Characterization Plan)

SAMPLING PLAN

February 1987

DRAFT

TABLE OF CONTENTS

APPENDIX A

APPENDIX B

TABLES

FIGURES

1. INTRODUCTION

CEARP Phase 2 Confirmation consists of CEARP Phase 2a, Monitoring Plan, and CEARP Phase 2b, Site Characterization (Remedial Investigation) This Sampling Plan is one component of the Monitoring Plan for Rocky Flats Plant The Monitoring Plan typically consists of five parts Synopsis, Sampling Plan, Technical Data Management Plan, Health and Safety Plan, and Quality Assurance/Quality Control (QA/QC) Plan Because of the Compliance Agreement between the State of Colorado, the Environmental Protection Agency, and the Department of Energy (DOE), this Monitoring Plan also includes a Feasibility Study Plan

CEARP uses a three-tiered approach in the preparation of monitoring plans the CEARP Generic Monitoring Plan (CGMP), the Installation Generic Monitoring Plan (IGMP), and the Site Specific Monitoring Plans (SSMPs) This revised IGMP serves as the Comprehensive Source and Plume Characterization Plan required by the Compliance Agreement Therefore, the acronym used to refer to this plan is IGMP/CSPCP

This IGMP/CSPCP Sampling Plan details specific guidance for implementation of CEARP Phase 2b site characterizations (remedial investigations) at Rocky Flats Plant and follows the guidance provided in the CGMP The Sampling Plan is complemented by and inseparable from the Technical Data Management Plan and the Quality Assurance/Quality Control (QA/QC) Plan Sections of the Sampling Plan are supported by reference to the other plans, and to the Synopsis Emphasis is placed on integration of efforts for each of the CEARP Phases Phase 3 (Technological Assessment), Phase 4 (Remedial Action), and CEARP Phase 5 (Compliance and Verification)

This IGMP/CSPCP Sampling Plan provides the following basic components of sample/measurement collection and analysis at Rocky Flats Plant

- objectives and goals of the investigation,
- methods and procedures and their justification,
- transportation and shipping information, and
- guidance for the site-specific investigations

The initial CEARP Phase 2 site characterization (remedial investigation) has provided considerable data to define regional and installation-wide geology, hydrology, and water quality These data will be further analyzed and interpreted as a first step of the site characterization (remedial investigation) being performed under this IGMP/CSPCP Monitoring Plan This analysis will define additional installation-wide data needs to enhance understanding of the surface water and groundwater pathways Some of these data needs have been identified, and are presented in Section 3 of this Sampling Plan Additional installation-wide sampling locations, soils boring locations, and monitoring well locations may be identified based on the results of these analyses.

Current understanding of the hydrogeological system and contaminant sources at Rocky Flats Plant has resulted in definition of several high-priority sites (DOE 1986f) These sites appear to be the primary sources of the known groundwater plumes Therefore, the installation-wide source and plume characterization (remedial investigation) will be accomplished by first evaluating these high-priority sites, tracing the contaminant plumes originating from these sites, and integrating these data on an installation-wide basis Second, all lower-priority sites will also be characterized and these data incorporated into the data base The details of the site-specific plume characterizations will be presented in the SSMPs The installation-wide characterization (remedial investigation) presented in this IGMP/CSPCP may be modified based upon the results of these site-specific analyses

The premise of this Sampling Plan is that installation-wide data needs are mostly satisfied by site-specific requirements Installation-wide needs encompass additional clarification of the sources contributing to and contaminant levels within the groundwater plumes, definition of interconnections and contaminant transport within the hydrogeologic system, and identification of gaps within the data base To address these needs, this Sampling Plan was organized as follows

- The remainder of the introduction outlines the objectives of the site characterization
- Section 2 presents the site survey and mapping criteria that ensure a common frame of reference
- Section 3 identifies installation-wide and site-specific data requirements

- Section 4 presents the sampling plan and rationale to be followed
- Section 5 identifies the sample numbering system
- Section 6 identifies sampling equipment and procedures
- Section 7 discusses sample analysis and handling
- Section 8 presents sample documentation and tracking procedures

1 1. INTEGRATED APPROACH

Sampling at Rocky Flats Plant will be conducted using an integrated approach The integrated approach is summarized in the Synopsis (Section 5 2) and detailed here The integrated approach breaks site characterization (remedial investigation) activities into stages, in which the results from previous stages of sampling are used to refine the conceptual model used to design successive stages of sampling This iterative process incorporates the experience and knowledge gained from each stage to minimize the total number of samples required to adequately characterize the site and to provide the necessary data base to prepare feasibility studies for alternative remedial actions The benefit of staged sampling is greater flexibility within the sampling program with a minimum of cost

1.2. OBJECTIVES OF THE SAMPLING PROGRAM

The overall objectives of CEARP Phase 2b site characterizations (remedial investigations) are to

- verify and characterize contaminant sources,
- determine the present areal and vertical extent of groundwater contamination plumes,
- estimate potential for contaminant migration (including rate and direction) to support risk assessment studies,
- support identification and technology assessments (feasibility studies) of alternative response actions, including the alternative of "no action," and
- support of long term monitoring and verification

These objectives are detailed for particular elements of the sampling program, as follows

1.2.1 Location of Waste Sites

The locations and boundaries of waste sites will be defined under CEARP Phase 2b site characterizations (remedial investigations) in order to delineate source areas for potential cleanup (e g , removal or containment) This will enable evaluation of the potential for migration of contaminants into the environment and evaluation of alternative remedial actions

1 2.2 Soils and Geology

Sampling of geologic materials at Rocky Flats Plant will include sampling of soils and waste materials found within the soils and bedrock The objective of this sampling is to confirm the types, concentrations, and extent of wastes and/or contaminant migration

Geotechnical characterization at Rocky Flats Plant will be performed to support the evaluation of waste migration (e g , sampling and testing for hydraulic properties) and to support the technological assessments (feasibility studies) of alternative remedial actions

1 2.3 Groundwater

The CEARP Phase 1 Assessment of Rocky Flats Plant recommended hydrogeochemical investigations of the aquifer systems in the immediate vicinity of the plant based on the ongoing hydrogeological studies An initial CEARP Phase 2b site characterization (remedial investigation) was conducted in 1986 with the objective of supplementing the existing hydrogeochemical understanding of the location, direction, rate of movement, recharge, and discharge of the hydrogeologic systems Under the revised IGMP/CSPCP, this investigation will be expanded to fill area-wide and site-specific hydrogeologic data gaps Ultimately, the investigation has the objective of providing a comprehensive data base for evaluating remedial actions

Existing groundwater quality data indicate that radioactive and chemical contaminants have entered the groundwater flow system As a result of this information radioactive and chemical contamination in groundwater will be a major focus of the site characterization (remedial investigation) activities The objectives of groundwater sampling are as follows

- Identify and characterize the source(s) of contaminants in the groundwater
- Determine the present areal and vertical extent of groundwater contamination
- Estimate the potential for contaminant migration (including rate and direction) to support risk assessment studies
- Support the identification and technology assessments (feasibility studies) of alternative remedial actions

1.2.4 Surface Water

Surface water was not identified as an important pathway for contaminant migration in the CEARP Phase I Installation Assessment All available surface water data are presented in the Geological and Hydrological Data Summary for Rocky Flats Plant (RI 1986c) The additional 42 surface water sampling locations used in the initial CEARP Phase 2 site characterization were selected based on these data and perceived data gaps Approximately half of these 42 stations were dry during the 1986 sampling season These stations will be sampled as part of the site characterization (remedial investigation) being conducted under this IGMP/CSPCP Monitoring Plan The primary objective of surface water sampling under this IGMP/CSPCP Sampling Plan is to support the characterization of the hydrogeochemical setting at Rocky Flats Plant by providing data on the interconnection between surface water and groundwater

1 2.5 Biota

The CEARP Phase I Assessment for Rocky Flats Plant and the Radioecology and Airborne Pathway Summary Report (RI 1986b) did not identify biota as a significant pathway for contamination There are no current plans for biological sampling

1.2.6. Air

The CEARP Phase I Assessment of Rocky Flats Plant and the Radioecology and Airborne Pathway Summary Report (RI 1986b) did not identify air as a significant pathway for contamination Existing air monitoring programs appear to have adequately characterized the air pathway, and there are no current plans for additional air pathway characterization However, air will be monitored under the health and safety program If this monitoring indicates that sampling activities are impacting the air pathway, more characterization data will be collected as appropriate

1.3. SCOPE

The sampling activities outlined in this Sampling Plan will be completed in two or more stages in line with the integrated approach being used by CEARP The scope of sampling and subsequent stages of sampling will be refined based on data analyses The anticipated scope of sampling corresponds to the data needs described in the Synopsis SSMP Sampling Plans will be prepared for each site or group of sites, as appropriate

Data collection activities that apply generically to all or most sites include the following

- geophysical and soil gas surveys to locate waste sites and describe metallic objects within wastes,

- land surveying to tie in geophysical surveys and provide precise locations of sites, and to provide a baseline for the location of sampling at sites, and

- aerial photography to identify waste sites and past waste disposal practices

1.3.1. Soils and Geology

Sampling of geologic materials and wastes will be conducted during the CEARP Phase 2b site characterizations (remedial investigations) Sampling may include both soil and soil gas sampling The scope of anticipated sampling includes the following

- sampling of soil gases using a field gas chromatograph, photoionization detector and/or organic vapor analyzer,

- sampling and analysis of soil to determine the presence, concentration, and distribution of potential contaminants, and

- sampling, analysis, and testing of soil in support of hydrogeochemical characterizations and engineering studies

1.3.2 Groundwater

Groundwater samples will be taken to refine the site-wide hydrogeological conceptual model and to determine the extent of contaminant migration within groundwater of the plant

The scope of groundwater characterization includes investigation of the quality of water within both the alluvium and bedrock This includes borings and monitoring well installation in areas adjacent to waste sites Surface geophysical methods and soil gas investigations are within the scope of this characterization

1.3.3 Surface Water

The scope of surface water characterization at Rocky Flats Plant includes sampling of streams, ditches, and seeps which might be impacted by contaminants

1 4 SCHEDULE

CEARP Phase 2b sampling activities at Rocky Flats Plant will begin at high-priority sites under the Site-Specific Monitoring Plan The sampling schedule is presented separately

2. SITE SURVEY AND MAPPING

Surveying and mapping will be conducted at an installation level to assure a common frame of reference for all site characterizations (remedial investigations) All monitoring stations will be surveyed unless a high degree of accuracy is determined unnecessary for a particular station Additional detail and guidance regarding site surveys and mapping is provided in the Technical Data Management Plan

2.1. INSTALLATION COORDINATE SYSTEM

All monitoring locations will be described in accordance with the Rocky Flats Plant Installation Coordinate System The plant coordinate system has been tied into the Colorado State Coordinate System using benchmarks established by the USGS Horizontal survey data will be reported in both Rocky Flats coordinates and State coordinates so data collected on plant site can be related to regional data as necessary Elevations will be reported in English units as feet above mean sea level

2.2 AREA OF INTEREST

The area of interest to be surveyed and mapped has been established according to the guidelines contained in the Technical Data Management Plan Rocky Flats Plant is contained within one property boundary Thus, the area of interest extends to the plant property boundaries

2.3 SCOPE OF WORK FOR SURVEYING

Tolerances of ±0 01 ft vertically and ±0 1 horizontally will be used in locating base stations and control points Tolerances of ±0 01 ft vertically and 1 ft horizontally will be allowed when surveying sampling locations

3 DATA REQUIREMENTS

This section presents an overview of the present situation and data requirements for installation-wide source and plume characterization at Rocky Flats Plant in accordance with the Compliance Agreement Also included are general requirements for CEARP Phase 2b site characterizations (remedial investigations) Detailed data collection requirements for specific sites will be presented in the appropriate SSMP Sampling Plans The goal of CEARP Phase 2b efforts is to collect sufficient data to meet the requirements of site characterizations, feasibility studies and risk/endangerment assessments, to identify alternatives for remedial action and to plan long term monitoring and verification

3.1 INSTALLATION DATA NEEDS

Installation-wide data needs have been identified as necessary to support the characterization of contaminant plumes, and to develop and continually refine conceptual models of contaminant transport The data required for installation-wide site characterization (remedial investigation) may be broken into four major categories sources, geology, groundwater, and surface water

This section presents a brief summary of the current environmental situation at the Rocky Flats Plant and identifies gaps in the existing data base Section 4 presents the Sampling Plan to fulfill identified data needs

3 1 1 Solid Waste Management Units

Solid Waste Management Units (SWMUs) were identified in the RCRA Part B Permit Application (DOE 1986b) Each of these solid waste managements units was assigned a reference number and located on an aerial photograph base map (Plate 1) This base map and a tabulation of all solid waste management units cross-referenced to the CEARP Phase I report is presented in the Rocky Flats Plant IGMP/CSPCP Synopsis

The locations and nature of solid waste management units at Rocky Flats Plant have been defined based on existing information (DOE 1986b, DOE 1986f) Further investigations of these solid waste management units should include precisely locating each unit and sampling in or near the unit to verify reported locations and contents

3.1.2. Soils and Geology

3.1.2.1 Geology

Available geologic data at Rocky Flats Plant consists of numerous regional and installation-specific geologic and geotechnical reports Stratigraphy and lithology are available from geotechnical investigations at the present landfill, the solar ponds, various onsite buildings, and from groundwater monitor well installations These data are presented in the Geological and Hydrological Data Summary for Rocky Flats Plant (RI 1986c) In addition, detailed mapping of surficial and bedrock geology at the plant was performed as part of the initial CEARP Phase 2b site characterization (remedial investigation) performed in 1986 in response to the Compliance Agreement

Surficial Geology Surficial deposits at Rocky Flats Plant consist of Rocky Flats Alluvium, several alluvial materials in the valleys, and colluvium The valley alluvial materials are Verdos Alluvium, Slocum Alluvium, recent terrace alluviums and recent channel deposits (valley fill) The general composition and lateral extent of surficial deposits were well defined by the 1986 mapping effort (DOE 1986f) The thickness and compositional variations of alluvium and colluvium were well defined where borehole data exist (DOE 1986f)

Additional installation-wide data on surficial geology are not considered necessary However, additional site-specific surficial geology data will be collected during monitor well installation as presented in the SSMP Sampling Plans

Bedrock Bedrock units beneath Rocky Flats Plant consist of Cretaceous Fox Hills Sandstone, Laramie Formation and Arapahoe Formation The Fox Hills Sandstone and lower Laramie Formation sandstones outcrop in clay pits west of the plant and were characterized by the 1986 geologic mapping (DOE 1986f) The upper Laramie Formation claystones subcrop beneath the Rocky Flats Alluvium in the western plant buffer zone, and the Arapahoe Formation subcrops immediately beneath and east of the plant Outcrops of these formations were located by the 1986 geologic mapping, however, the contact between the Laramie and Arapahoe Formations could not be positively identified in the field (DOE 1986f) Based on boring logs, the contact was estimated to be below the the first Arapahoe sandstone that was greater than 5 ft thick (DOE 1986f)

Because the Arapahoe Formation subcrops beneath and east (downgradient) of the plant, the locations and extent of sandstone bodies within the formation are important to an understanding of the bedrock flow system and contaminant transport During the initial CEARP Phase 2b site characterization (remedial investigation), bedrock wells were cored to the first total sandstone cumulative thickness of 3 ft within a 10-ft interval, and bedrock monitor wells were completed in these sandstones This drilling program identified numerous sandstone bodies at various depths beneath the plant which were previously unidentified The sandstones are lenticular, discontinuous and stratigraphically complex (DOE 1986f)

An installation-wide bedrock investigation may be necessary to support the quantification of groundwater flow patterns and solute transport in the groundwater If warranted, based on plume characterizations, additional core data will be collected to determine the extent of known sandstones and to locate previously unidentified sandstone lenses

3 1.2.2 Geotechnical

Geotechnical tests have been conducted on materials from many of the onsite borings Data collected to date include standard penetration tests, Atterburg limits, and grain-size analyses of various materials (RI 1986c) Cores have been collected during the initial CEARP Phase 2b site characterization (remedial investigation) that will be tested to evaluate permeabilities, porosities, and physical properties of bedrock and alluvial units in support of hydrogeologic characterization Based on the results of these tests, additional installation-wide data needs may be identified

3.1.3 Groundwater

3 1.3 1 Hydrology

There are two hydraulically-connected groundwater flow systems at Rocky Flats Plant These occur in the Rocky Flats Alluvium and other surficial materials, and in the bedrock (primarily in the claystones and sandstones of the Arapahoe Formation)

Presented below is a discussion of each flow system and the data needs to support potential groundwater modeling efforts

Shallow Flow System The shallow alluvial groundwater system in the Rocky Flats Alluvium and other surficial materials occurs under unconfined conditions The system is recharged by infiltration of incident precipitation and surface water Shallow groundwater flow generally follows topography to the east and toward the drainages Discharge areas are springs and seeps at the alluvium/bedrock contact and major drainages The shallow system appears to be quite dynamic, as large water table fluctuations occur in response to seasonal stresses As a result of these fluctuations, large unsaturated zones within the system occur during certain portions of the year

Shallow groundwater flow rates were calculated based on single-hole drawdown-recovery test data collected during the initial CEARP Phase 2b site characterization (remedial investigation) (DOE 1986f) Data available to date indicate mean hydraulic conductivities as follows

Material	Hydraulic Conductivity (cm/sec)
Rocky Flats Alluvium	7×10^{-5}
Walnut Creek Alluvium	3×10^{-5}
Woman Creek Alluvium	3×10^{-3}

The effective porosity of alluvial materials is assumed to be 0 1 (Hurr 1976) Based on the hydraulic conductivities presented above, an assumed effective porosity of 0 1, and gradients determined from the initial CEARP Phase 2 site characterization, groundwater velocities were calculated for each geologic unit listed above The horizontal velocity is approximately 14 ft per year in the Rocky Flats Alluvium, approximately 900 ft per year in Woman Creek alluvium and approximately 9 ft per year in Walnut Creek alluvium Dissolved chemical species do not migrate as far as implied by the velocity calculations because the surficial materials are not saturated year-round Portions of the Rocky Flats Alluvium are probably saturated throughout the year, and conservative (nonattenuated) species in Rocky Flats Alluvium ground-water could travel annual distances of the order calculated However, conservative species in valley fill groundwater cannot travel the predicted distances because these materials are dry during portions of the year (1986f)

The shallow flow system at Rocky Flats Plant is generally understood, however, additional flow data are needed for a detailed understanding of the system Seasonal water level fluctuations and unsaturated zones within the system need to be better defined on an installation-wide scale to describe the dynamic groundwater flow system Hydraulic conductivity and effective porosity values also need to be determined in the field for the Woman Creek Alluvium to support a quantitative evaluation of solute transport at Rocky Flats Plant

Bedrock Flow System Most groundwater flow in the Arapahoe Formation occurs in lenticular sandstone bodies contained within the claystones Recharge to the sandstones occurs by leakage through the claystones or where the sandstones are in direct contact with saturated surficial materials Groundwater in the sandstones flows east toward the point of regional discharge along the South Platte River

Groundwater flow rates estimated by DOE (1986f) were based on the initial CEARP Phase 2 site characterization (remedial investigation) and regional data Based on single-hole drawdown-recovery tests and packer tests, the sandstones have an average hydraulic conductivity of 2 x 10^{-6} cm/sec Average hydraulic conductivity values for weathered and unweathered claystone were developed using packer test data These values were approximately 5 X 10^{-7} cm/sec for weathered claystone and 1 x 10^{-7} cm/sec for unweathered claystone Assuming an effective porosity of 0 1 and the regional gradient, the horizontal velocity of the sandstones was estimated to be approximately 0 6 ft per year (DOE 1986f)

There is a strong downward gradient between the shallow and bedrock flow systems (DOE 1986f) These gradients range from 0 20 to 1 0 based on onsite water level data from paired bedrock and shallow wells No vertical conductivity values are available for the claystones, however, a value one-third of the horizontal conductivity of 1 x 10^{-7} was assumed in order to calculate a downward groundwater velocity of 0 1 ft per year (DOE 1986f)

Additional data are needed to better define bedrock flow directions and velocities at Rocky Flats Plant Refined horizontal and vertical hydraulic conductivity as well as effective porosity values are needed for the sandstones and claystones to further evaluate groundwater flow velocities and solute transport Further testing of well pairs is also needed to investigate vertical gradients between the shallow and bedrock flow systems

3.1.3.2 Quality

Groundwater conditions at Rocky Flats Plant have been monitored since 1961 and chemical data exist for monitoring over the past ten years In addition, groundwater samples were collected from 27 existing wells and the 69 new wells during the initial CEARP Phase 2 site characterization (remedial investigation) (Plate 2) Based on these data, a one-time characterization of alluvial and bedrock water quality is presented in the RCRA Part B Permit Application (DOE 1986f) and summarized in the IGMP/CSPCP Synopsis This characterization includes a discussion of background and downgradient water quality Because the groundwater quality discussion presented by DOE (1986f) is based on a one-time sampling event, seasonal water quality fluctuations need to be evaluated on an installation-wide basis Quarterly groundwater quality data are being collected as specified in the RCRA Part B Operating Permit Application In addition, site-specific groundwater quality will be evaluated during CEARP Phase 2b site characterizations

3 1 4 Surface Water

3 1 4 1 Hydrology

Three intermittent streams drain Rocky Flats Plant Flow is generally from west to east Rock Creek drains the northwestern corner of the plant site and flows to the northeast toward its offsite confluence with Coal Creek Woman Creek drains the southern portion of the plant site and flows eastward to Standley Lake North and South Walnut Creek and an unnamed tributary drain the remainder of the plant site A series of dams, retention ponds, diversion structures and ditches have been constructed at the plant to control surface water and limit the potential for release of poor quality water A detailed discussion of this system is presented in the RCRA Part B Permit Application (DOE 1986f)

The surface water flow system is well understood and documented (DOE 1986f) Surface water flow needs to be monitored on an installation-wide scale to describe seasonal fluctuations in flows and to support groundwater flow and solute transport modeling

3.1.4 2. **Quality**

Surface water quality is characterized in detail in the RCRA Part B Permit Application (DOE 1986b) This characterization is based on a one-time site characterization sampling event and NPDES monitoring The initial CEARP Phase 2 site characterization (remedial investigation) characterized surface water hydrology by measuring flow rates and sampling surface water at onsite sampling stations (Plate 2)

Surface water discharged from retention ponds is monitored regularly to document compliance with NPDES permit requirements The NPDES permit is issued and regulated by EPA and requires the plant to monitor for specific pollutants at seven discharge locations These seven discharge locations are pond B-3 (discharge 001), pond A-3 (discharge 002), Reverse Osmosis Pilot Plant (discharge 003), Reverse Osmosis Plant (discharge 004), pond A-4 (discharge 005), pond B-5 (discharge 006) and pond C-2 (discharge 007) Sanitary effluent limitations are placed on pond B-3 (sewage effluent), and limitations for nitrate and pH are placed on pond A-3 Discharge limits apply to the Reverse Osmosis Plant, and limitations on sediment release apply to ponds A-4, B-5 and C-2 In addition to NPDES permit requirements, all of these discharges are monitored for pH, nitrate as nitrogen, nonvolatile suspended solids, plutonium, americium, uranium, and tritium (RI 1986a)

Surface water quality was characterized by DOE (1986f) However, continued monitoring of NPDES discharge locations and the other surface water sampling locations is necessary to define seasonal fluctuations in surface water quality

3 2. SITE-SPECIFIC DATA NEEDS

Data needs at the solid waste management units may be separated into three major categories soils and geology, groundwater, and surface water

3 2.1. Soils and Geology

3 2.1.1 Soils and Wastes

Data needs for soils include geotechnical data (e g, grain size, clay content, moisture content, compaction, and permeability), vadose zone data (e g, adsorptive capacity, buffering capacity, and pore fluids and soil chemistry), and variability of these parameters Collection of soil data may be accomplished by detailed soil sampling and testing and/or installation of soil water samplers as necessary In addition, the extent of surficial contamination may be investigated by collecting surface soils and screening them for radioactive materials

Data needs for waste characterization will include sources, site boundaries, physical state, composition, and concentrations of waste materials

3 2.1.2 Geology

Geologic data needs include depth and composition of surficial materials, the local extent and lithology of existing sandstones, and the geotechnical characteristics of both surficial and bedrock materials

3 2.2 Groundwater

Groundwater data needs include the monitoring of water levels, the determination of water quality and hydraulic conductivity, definition of local stratigraphy and lithology, and quantification of seeps to surface Tasks designed to fill groundwater data needs at the high-priority sites will include installation of monitoring wells in both alluvium and bedrock, sampling and geotechnical testing of alluvial and bedrock materials, and sampling and analysis of groundwater The elevation of groundwater will be measured in wells and at seeps to provide data for determination of ground-water flow directions A complete description of the tasks to be implemented will be presented in the individual SSMP Sampling Plans

3.2.3. Surface Water

Surface water data needs include topographic mapping, interceptor ditch flow, surface water flow and quality, and their variability The surface water investigation will include preparation of detailed topographic maps of each area of investigation to determine drainage area characteristics Water samples from the interceptor ditches and creeks will be collected from multiple locations upstream, adjacent to, and downstream from the area being investigated Stream flow data may be collected from existing gauging stations or new installations

4 SAMPLING PLAN AND RATIONALE

4 1. INSTALLATION-WIDE SAMPLING PLAN

The first task of this Sampling Plan will be to review all available data so that a conceptual understanding (model) of the existing system can be developed The second task will be to identify specific locations where sampling and testing are to be conducted to test the conceptual model Discussion of the probable techniques to be used for collecting data is provided below

4 1 1 Soils and Geology

4 1 1.1. Soils and Wastes

Characterization of suspected waste sites will be conducted on a site-specific basis (Section 4 2) Characterization will include source locations, waste compositions, and evaluation of potential migration pathways As stated in the introduction, most of the installation-wide characterization (remedial investigation) needs will be satisfied by activities carried out under site-specific investigations These site-specific data will be used as input to the mathematical model(s) that will be used to evaluate contaminant transport through the various pathways on an installation-wide basis Additional data needs identified by this modeling effort will then be identified

4 1 1 2 Geology

Additional investigations of the geology at Rockv Flats Plant are anticipated to be confined to collection of site-specific data Data to be generated include the thickness and composition of alluvial deposits, the local extent and lithology of sandstone units, and geotechnical parameters of both bedrock and alluvial deposits

4.1.2 Groundwater

Characterization of groundwater flow and quality has been identified as an installation-wide data need Characterization of contaminant plumes in either alluvial or bedrock units will be initiated on a site-specific basis

Techniques to be used in developing these data may include multiple well-pumping tests, slug tests, and tracer tests. Monthly groundwater elevation measurements of all wells will be conducted for at least one year in order to determine seasonal variation in the potentiometric surface. Drilling and installation of additional groundwater monitoring wells in locations where data are lacking may be necessary.

The extent of groundwater quality data needs will be more accurately evaluated following reviews of the available data and the newly acquired site-specific data. All new and existing monitoring wells will be monitored quarterly to adequately characterize seasonal and spatial variation in groundwater quality.

4.1.3. Surface Water and Sediment

Characterization of surface water flow and surface water quality will be investigated on an installation-wide basis. Quarterly sampling of surface water in each drainage will be necessary to detect seasonal variation in surface water quality. Discharge information may be collected and evaluated from multiple locations on each drainage to further characterize surface water flow patterns and to evaluate the relationship between surface water and groundwater.

Sediment quality was characterized during the initial CEARP Phase 2 site characterization (remedial investigation) (DOE 1986f). On an installation-wide basis, additional sediment samples are not deemed necessary.

4.2 GUIDANCE FOR THE SITE-SPECIFIC SAMPLING PLANS

This section provides a brief overview of the planned environmental monitoring and site-specific characterization activities at Rocky Flats Plant. Detailed discussions of the site-specific sampling efforts and rationale will be included in the SSMP Sampling Plans.

4.2 1. Soils and Geology

4 2 1 1 Soils and Wastes

The delineation of waste site boundaries is an identified data need (Section 2 of the Synopsis) Geophysical surveys will be conducted to delimit the boundaries and identify some characteristics of waste sites The surveys will be tied in to the Installation Coordinate System and established benchmarks The surveys will include a sampling network specific to each potential waste site identified in the SSMPs, with systematic sampling on a grid basis

Specific geophysical techniques to be applied at Rocky Flats Plant are expected to include electromagnetic induction (EM), magnetometry, metal detection, and vertical electrical resistivity Electromagnetic induction and visual inspection will be used as the primary means of locating areas of disturbed soil It will also be used for reconnaissance of chemical spills Magnetometry and metal detection will be used to locate buried metallic objects The location of metallic objects will provide data on past burial operations and will be used as a guide for drilling locations to avoid drilling into those objects Resistivity will be used, as appropriate, to develop data on the vertical extent of the source areas

Sampling of soil and wastes will be conducted to confirm the extent and characteristics of potential contaminants and contaminant migration After waste site boundaries are delineated by the geophysical survey, the waste sites will be sampled using both soil gas sampling and soil borings

The specific number, location, depth, sampling interval, and requisite analyses for both direct and indirect samples will be specified in the SSMPs

4 2.1 2 Geology

Detailed investigation of the geology of each site to be characterized is needed in order to evaluate (1) the depth and composition of alluvial materials, (2) the local extent and lithology of sandstones, and (3) the geotechnical characteristics of both the alluvial and bedrock deposits

Borings and cores at selected locations through the alluvium and into bedrock will be used to generate geologic data Samples of each unit will be collected and lithologically described to generate data on the composition and extent of geologic materials Techniques for sample collection and description are included in Appendix A

4.2.1 3 Geotechnical

Site-specific geotechnical data will include laboratory tests to evaluate permeabilities, effective porosities, and physical properties of bedrock and alluvial units Installation needs will be identified as appropriate Falling head permeability tests will be performed on bedrock cores to investigate horizontal and vertical laboratory permeabilities, and capillary moisture tests will be conducted on bedrock cores to estimate effective porosities At least three samples of each bedrock unit will be tested to account for sample variability

If existing data does not include physical properties data, physical properties tests will be performed on appropriate bedrock and alluvial materials Physical properties tests will consist of grain-size analyses, Atterburg limits, and water content tests Hydrometer tests will be performed if more than 50 percent of a sample passes the 200-mesh sieve Physical property test results will be used to develop a basis for selecting monitor well screen and filter pack sizes, to compare visual field classifications on boring logs with laboratory results, and to calculate permeability values based on empirical correlations to physical properties

4 2 2 Groundwater

Specific tasks to be completed in order to characterize the hydrogeology of Rocky Flats Plant are expected to include soil gas surveys, monitor well installation and sampling, and surface water sampling Soil gas surveys will be completed in order to detect the distribution of volatile organic contaminants within the groundwater as well as to assist in locating source areas Installation and sampling of groundwater monitoring wells will provide data on the flow and quality of groundwater in the vicinity of the sites

4 2.3 Surface Water

Sampling of surface water will provide data on the potential impact of groundwater on surface water quality

4 2.4 Air

Monitoring of air for particulates and organic vapors will be maintained on a site-specific basis during invasive sampling (i e, soil boring) for the purpose of protecting the health and safety of the sampling team This monitoring will be used to determine the need, if any, for additional air quality sampling during site characterizations (remedial investigations) Specific air monitoring procedures to be used during invasive sampling will be specified in the SSMP Health and Safety Plans

5. SAMPLE NUMBERING SYSTEM

Each sample collected for chemical analysis, including replicates, blanks, and quality control check samples, will be identified by a unique sample identification number Samples are identified by installation (Rocky Flats Plant), location (i e, well number), sample matrix, sample ID, date, and lot control number (for tracking lots associated with a particular blank, replicate, or quality control check sample) Sample results will be reported by matrix on the same basis

Location ID and sample ID, including all of the above information, will be assigned by the subcontractor site manager These data identifiers will be assigned prior to field activities Field personnel will carry a list of designations, keyed to a map, into the field with them

Additional locations may be assigned while field teams are onsite, if warranted If additional locations are assigned during field activities, they will be documented by the field team It will be the responsibility of the field team leader to make sure a "Location Information" form is completed A copy of the form is included in Appendix B of the Technical Data Management Plan

6 SAMPLING EQUIPMENT AND PROCEDURES

This section presents general procedures to be followed during the site characterizations (remedial investigations) at Rocky Flats Plant Equipment and procedures to be used are presented in Appendix A

6.1. SURFACE SOIL SAMPLES

Samples of surficial soil material may be collected from onsite areas of Rocky Flats Plant using a spade or scoop The samples will be placed into the appropriate sample container, labeled, and transported to the laboratory, where they will be screened for radioactive contamination The sampler will be decontaminated prior to each use in accordance with the standard protocol presented in Appendix A

6 2. SOIL SAMPLES COLLECTED DURING DRILLING

Soil borings will be performed to characterize the nature and volume of wastes General drilling and logging procedures are described in Appendix A Site-specific modifications to these procedures will be included in individual SSMPs

6.2.1 Samples for Laboratory Analysis

Continuous drive samples will be collected from the ground surface to total depth where possible Total depth will vary depending on visual description of samples (i e, presence of stains for metals) and qualitative screening for organics and radionuclides

In general, up to six samples from each boring at suspected waste sources may be submitted for laboratory analysis Screening will be used to determine which samples to submit for laboratory analysis The purpose of screening is to obtain a preliminary indication of the magnitude and distribution of volatile contaminants, metals, and radionuclides in the subsurface Selection of the samples will be based on the screening (visual, radiation, and organic vapors) Samples from the core at the following locations may be submitted to the laboratory

- directly above the waste
- in the most contaminated zone of the waste
- directly below the waste
- at the base of the surficial material
- within the bedrock near the bedrock/alluvial contact

The exact location of the samples will be determined by interpretation of the visual characteristics, and radiation and organic vapor measurements Two samples characterizing the most contaminated zone of the waste may be submitted should the zones of highest radiation and volatile organics not correlate Also, a sample directly above the waste may not be submitted for analysis should this zone be at or near the surface, because the surface will adequately demark the upper bounds of the waste Should the waste be located within the bedrock, only one coring below the waste will be submitted

Soil samples will be collected from soil borings near waste sources to determine the extent and magnitude of soil contamination Visual, radiation, and organic vapor screening will be used to determine which samples to submit for laboratory analysis In general, up to three samples will be submitted for analysis

Sampling equipment will be decontaminated prior to each use in accordance with the standard protocol presented in Appendix A

6.3 MONITORING WELL INSTALLATION

Monitoring wells will be installed on a site-specific basis to characterize groundwater quality Their locations will be based on geophysical and soil gas surveys

General procedures for the installation of monitoring wells are described in Appendix A

6 3.1. Installation of Soil Water Samplers

Soil water samplers (lysimeters) may be installed for characterization of the vadose zone A procedure for the installation of soil water samplers is included in Appendix A

6.3.2. Installation of Soil Water Monitors

Various devices to monitor soil suction or soil moisture content may be installed (e g , tensiometers, neutron probe access tubes, thermocouple psychrometers, and resistance blocks) The specific devices will be detailed in the SSMP Sampling Plans Procedures for installation of tensiometers are included in Appendix A

6 4 GROUNDWATER SAMPLES

Migration through groundwater has been identified as a significant potential pathway for release of contaminants to the environment at Rocky Flats Plant Sampling of groundwater is necessary to evaluate the degree of groundwater contamination which has occurred as well as the potential for future contaminant migration

All wells will be purged before sampling Procedures for well sampling and purging are presented in Appendix A

6.5. HYDRAULIC TESTS

Groundwater systems may be tested to characterize hydraulic properties such as hydraulic conductivity and effective porosity, to calculate groundwater flow velocity, and to estimate other properties important to contaminant migration Procedures for drawdown-recovery tests of monitoring wells are included in Appendix A

6 6 SURFACE WATER SAMPLES

Surface water samples will be collected from streams, ditches, and seeps to assist in characterizing the hydrogeochemistry of Rocky Flats Plant The samples will be collected according to the protocol presented in Appendix A

6.7 STORAGE AND DISPOSAL OF DRILLING AND SAMPLING WASTES

Sampling and drilling activities could generate potentially hazardous solid and liquid "wastes". The activities, anticipated type and amount of waste, and planned handling of the wastes are summarized below

- Waste boring sampling solid, auger cuttings and excess soil/cuttings collected but not retained in sample containers--returned to borehole upon completion (bentonite plugs placed at the base of the borehole to approximately 2 ft above the base of waste material and also at the surface of the borehole), liquid--none

- Surface soil sampling solid, any excess soil from that collected for the composite--returned to holes created by sample collection, liquid--none

- Sediment sampling solid, any excess sediment collected in auger but not retained in jars--left at sampling site, liquid--none

- Surface water sampling solid--none, liquid--none

- Monitoring well installation solid, bulked in drums for screening and/or composite testing and appropriate disposal when taken from suspect contaminated sites, otherwise left on land surface adjacent to well, liquid--none

- Vadose zone monitor installation solid, bulked in drums for composite testing and appropriate disposal when taken from suspect contaminated sites, otherwise, left on land surface adjacent to bore holes, liquid--none

- Pump testing liquid, discharged to plant waste treatment system when testing at a suspect contaminated site, otherwise, disposed of on ground surface

- Groundwater purging/sampling solid--none, liquid, purged from wells prior to sampling discharged to plant waste treatment system when testing at a suspect contaminated site, otherwise, disposed of on ground surface

Disposal of any bulked "wastes" will depend on analytical test results of samples taken to characterize the wastes One composite sample will be taken on a site-by-site basis Testing will be done for EP toxicity, hazardous characteristics Hazardous Substance List (HSL) organics, and radioactive materials to determine acceptability at the Rocky Flats Plant waste treatment facilities If the material cannot be accepted by the Rocky Flats Plant waste treatment and/or disposal facilities, it will be disposed of at an appropriate offsite facility Solid wastes such as disposable booties, Tyvek, contaminated paper, and Saran Wrap, will be considered hazardous for disposal purposes, the subcontractor site manager will ensure that wastes are disposed of in an approved manner

7. SAMPLE ANALYSIS AND HANDLING

The testing program for samples collected during implementation of this Sampling Plan will be summarized in individual SSMPs All water sampled (i e , surface water, effluents, soil water, and groundwater) will be tested in the field for pH, specific conductance, and temperature The water, waste, and soil samples will be tested for select organic, inorganic, and radiological parameters using the analytical methods detailed in the IGMP/CSPCP Quality Assurance/Quality Control Plan

7.1. SAMPLE CONTAINERS AND PRESERVATION

Sample containers and preservation are presented in Tables 7 1 and 7 2 Analytes will be identified on a site-specific basis in the SSMPs Although initial sampling should not include collection of other than low-hazard environmental samples, guidance regarding high-, medium-, and low-hazard samples is provided

7.1.1 High-Hazard Samples

High-hazard samples collected for chemical analysis, those collected from drums, tanks, or spills, where they have not been diluted by environmental conditions, will be contained and preserved in accordance with EPA protocols listed in Table 7 1 These samples will be shipped directly to the laboratory for preparation of extracts The analysis to be performed must be specified at the time the high-hazard sample preparation is scheduled All high-hazard samples will be placed in 8-oz wide-mouth glass jars, sealed in paint cans, and marked as hazardous No preservatives are required for high-hazard samples

Samples collected in locations where radioactive contamination could occur will be screened in the field It is not anticipated that any samples will qualify as radioactive under DOT regulations

7.1.2. Medium-Hazard Samples

Medium-hazard samples are those that have originated from drums or concentrated residues, but that have been diluted somewhat by environmental conditions Medium-hazard samples will be contained, preserved and shipped as appropriate for testing in accordance with EPA protocols listed in Table 7 2 All medium-hazard sample containers will be placed in paint cans and marked as hazardous In all other respects, medium-hazard samples are treated in the same manner as low-hazard samples

7 1.3 Low-Hazard Samples

Low-hazard samples are environmental samples in which contaminants have been significantly diluted by the environment Low-hazard samples will be contained and preserved as appropriate for testing in accordance with EPA protocols listed in Table 7 2 If necessary, samples will be placed on ice immediately after collection to maintain a temperature of 4°C

Most groundwater samples collected for soluble inorganic metals analysis will be filtered in the field or at an onsite laboratory as soon as possible after collection but prior to the addition of nitric acid preservative Filtering will be done with a pressure filtration device and 0 45-micron filter Surface water samples and groundwater samples collected for total metals analysis will not be filtered prior to acid preservation

7 1.4 Radiological Samples

Radioactive contamination of soils and water is of concern at Rocky Flats Plant Only low-level samples are anticipated, however, samples will be screened in the field to confirm that expectation All soil samples to be analyzed for radionuclides (e g , tritium, uranium, plutonium, americium, and strontium) will be collected, contained, and preserved according to protocols specified for metals and cyanide in soil and sediment (Table 7 2) All water samples to be analyzed for these parameters will be collected, contained, and preserved identically to low-concentration minerals in water (Table 7 2)

7.2. SAMPLE PACKAGING AND SHIPMENT

7.2.1. High-Hazard Samples

In preparation for shipment to the analytical laboratories, all high-hazard samples will be packaged in accordance with the following procedures

- Sample container caps will be tightened securely and sealed with tape, liquid levels will be marked if bottles are partially full

- Sample labels will be securely attached to the sample container, each sample container will be placed in a zip-loc baggie (TM), ensuring that labels can be read

- All bagged sample containers will be placed in paint cans, and the cans will be filled with vermiculite

- The paint cans will be placed in a cooler lined with two inches of vermiculite or equivalent absorbent packing material, each paint can will be surrounded by packing material and all remaining space in cooler will be filed with additional packing material

- Chain-of-custody forms will be placed in a manila envelope, the envelope will be placed in a zip-loc baggie (TM) and taped to the inside of the cooler lid

- The cooler will be closed and sealed shut with strapping tape, if the cooler has a drain port, it will be sealed shut with tape, custody seals will be placed across the closure at the front of the cooler

- The cooler will be marked with labels indicating hazardous substances

- If shipped offsite, the shipper's and consignee's addresses will be fixed to the top of the cooler, if the samples are liquid, "This End Up" labels will be placed appropriately

- The cooler will be shipped to a laboratory

High-hazard samples will be shipped within twenty-four hours of collection if sent to an offsite laboratory

7 2.2 Medium-Hazard Samples

Medium-hazard samples will be packaged in the same manner as high-hazard samples Organics samples will be shipped within twenty-four hours of collection if sent to an offsite laboratory Inorganics samples will be shipped within forty-eight hours if sent to an offsite laboratory

7 2.3 Low-Hazard Samples

In preparation for shipment to the analytical laboratories, all low-hazard samples will be packaged in accordance with the following procedures

- The sample will be checked for proper preservation, the sample container cap will be tightened securely and sealed with tape, liquid levels will be marked if bottles are partially full

- Sample labels will be securely attached to the sample container, each sample container will be placed in a zip-loc baggie (TM), ensuring that labels can be read

- The bagged sample containers will be placed in a cooler lined with two inches of vermiculite or equivalent absorbent packing material, each sample will be surrounded by packing material and all remaining space in the cooler will be filled with additional packing material

- Chain-of-custody forms will be placed in a manila envelope, the envelope will be placed in a zip-loc baggie (TM) and taped to the inside of the cooler lid

- The cooler will be closed and sealed shut with strapping tape, if the cooler has a drain port, it will be sealed shut with tape, custodv seals will be placed across the closure at the front of the cooler

- If shipped offsite, the shipper's and consignee's address will be affixed to the top of the cooler, if the samples are liquid "This End Up" labels will be placed appropriatelv

Samples for organic analyses will be shipped within twenty-four hours of collection if sent to an offsite laboratory Samples for inorganic analyses will be shipped within forty-eight hours of collection if sent to an offsite laboratory

7 2 4. **Radiological Samples**

Environmental samples for radiological analysis should be low-hazard and if shipped offsite will be shipped according to the procedures for low-hazard samples Samples collected during soil sampling will be screened for radioactivity Should radioactivity levels exceed DOT criteria for classification as radioactive (specific activity greater than 0 002 microcuries per gram), they will be labeled and shipped according to DOT regulations if sent offsite

Table 7.1 Required Sample Containers and Preservation for High-Hazard Samples[1]

Testing	Containers	Preservation
Organics in Water and Liquids (High Concentration)		
All Organics Analysis	One 8-oz wide-mouth glass jar with Teflon-lined cap, filled 3/4 full	None required
Inorganics in Water and Liquids (High Concentration)		
All Inorganics Analysis	One 8-oz wide-mouth glass jar, filled 3/4 full	None required
Fluoride	One 500-ml polyethylene bottle filled to shoulder	None required
Organics in Soil and Sediment (High Concentration)		
All Organics Analysis	One 8-oz wide-mouth glass jar with Teflon-lined lid, filled 3/4 full	None required
Inorganics in Soil and Sediment (High Concentration)		
All Inorganics Analysis	One 8-oz wide-mouth glass jar, filled 3/4 full	None required
Fluoride	One 500-ml polyethylene bottle filled to shoulder	None required

[1] All high-hazard sample bottles must be shipped in paint cans as hazardous

Table 7.2 Required Sample Containers and Preservation[1] for Medium and Low Hazard Samples

Testing	Containers	Preservation
Organics in Water and Liquids (Medium Concentration)[2]		
Extractables (acid, base/neutral, pesticides/PCB)	Four 32-oz wide-mouth glass jars with Teflon-lined caps, filled to neck	None required
Volatiles	Two 40-ml VOA vials with Teflon-lined caps, completely filled--no air bubbles	None required
Inorganics in Water and Liquids (Medium Concentration)[3]		
Metals	One 16-oz wide-mouth glass amber bottle, filled to shoulder	1 1 HNO_3 to pH<2
Cyanide	One 16-oz wide-mouth glass amber bottle; filled to shoulder	6N NaOH to pH>12
Total Suspended Solids, Total Dissolved Solids	One 500-ml high density polyethylene bottle, filled to shoulder	None required
Minerals		
Acidity	One 500-ml high-density polyethylene bottle, filled to shoulder	Cool 4°C
Alkalinity		Cool 4°C
Chlorine		Room temperature
Fluoride		Room temperaure
Sulfate		Cool 4°C
Nutrients		
Ammonia	One 1-liter polyethylene bottle filled to shoulder	1 ml 1 1 H_2SO_4 to pH<2, cool 4°C
COD		
TKN		
NO_3-NO_2		
TOC		
Total Phosphorous		

Table 7 2 (Continued)

Testing	Containers	Preservation
Organics in Soil and Sediment (Medium Concentration)		
Extractables (acid, base/ neutral, pesticides/PCB)	One 8-oz, wide-mouth glass jar with Teflon-lined lid, filled about 3/4 full	None Required
Volatiles	Two 120-ml glass vials with Teflon-lined lid, filled as completely as possible	None Required
Inorganics in Soil and Sediment (Medium Concentration)		
Metals and Cyanide	One 8-oz, wide-mouth glass jar, filled about 3/4 full	None Required
Organics in Water and Liquids (Low Concentration)		
Extractables (acid, base/ neutral, pesticides/PCB)	Two 1/2-gal glass amber bottles with Teflon-lined caps, filled to neck	Iced to 4°C
Volatiles	Two 40-ml VOA vials with Teflon-lined caps, completely filled--no air bubbles	Iced to 4°C
Inorganics in Water and Liquid (Low Concentration)[3]		
Metals	One 1-liter high-density polyethylene bottle, filled to shoulder	1 1 HNO_3 to pH<2
Cyanide	One 1-liter high-density polyethylene bottle, filled to shoulder	6N NaOH to pH>12
Total Suspended Solids, Total Dissolved Solids	One 500-ml high-density polyethylene bottle, filled to shoulder	None Required

Table 7 2 (Continued)

Testing	Containers	Preservation
Minerals		
Acidity	One 500-ml high-density polyethylene bottle, filled to shoulder	Cool $4^{o}C$
Alkalinity		Cool $4^{o}C$
Chloride		Room temperature
Fluoride		Room temperature
Sulfate		Cool $4^{o}C$
Nutrients		
Ammonia	One 1-liter polyethylene bottle filled to the shoulder	1 ml 1 1 H_2SO_4 to pH<2, cool $4^{o}C$
COD		
TKN		
NO_3-NO_2		
TOC		
Total Phosphorous		
Organics in Soil and Sediment (Low Concentration)		
Extractables (acid, base/ neutral, pesticides/PCB)	One 8-oz, wide-mouth glass jar with Teflon-lined lid, filled about 3/4 full	Iced to $4^{o}C$
Volatiles	One 8-oz glass vial with Teflon-lined lid, fill as completely as possible	Iced to $4^{o}C$
Inorganics in Soil and Sediment (Low Concentration)		
Metals and Cyanide	One 8-oz, wide-mouth glass jar, filled about 3/4 full	Iced to $4^{o}C$ (optional)

[1] All medium-hazard sample bottles must be shipped in paint cans marked as hazardous

[2] Water samples collected for duplicate analysis must be collected at double the volume specified for organics and inorganics In addition, one volatile trip blank (distilled-deionized water poured directly into two 40-ml vials) should be supplied per shipment

[3] If sample preservative is required, pH will be monitored to assure proper adjustment

8 SAMPLE DOCUMENTATION AND TRACKING

8 1 FIELD RECORDS

Field observations and other pertinent information pertaining to sample collection will be recorded in bound field notebooks using black ink Data will be recorded on field data records contained in Appendix B of the Technical Data Management Plan and entered into the data base as described in the Technical Data Management Plan

Notebooks shall be assigned to field personnel Each notebook will be identified by a Document Control Number The cover of the notebook will contain the following information organization, book number, project name, start date, and end date

8.2. CHAIN-OF-CUSTODY PROCEDURES

All samples will be collected and handled in accordance with the chain-of-custody procedures listed below

- Samples will be kept in the possession or sight of at least one sampling team member at all times, unless transferred to a secure, locked area
- A sample ID tag, including predesignated location ID and sample ID will be affixed in the field
- Prior to relinquishing samples for packaging and shipment, one member of the sampling team will fill out a chain-of-custody record (Figure 8 1) for all team members to sign
- If samples are stored temporarily prior to shipment, they will be kept cool and placed in a secured storage area Coolers will be sealed and custody seals affixed just prior to shipment.
- If custody is transferred to the Shipping and Receiving Department at Rocky Flats Plant, the recipient will sign the chain-of-custody form.
- Shipping receipt for shipment by courier (above) should be retained and kept with one copy of the chain-of-custody form

8 3 PHOTOGRAPHS

In addition to written records, photographs will be taken as needed to further clarify sampling activities The film roll number and number of photographs taken at each sampling location will be noted

Custody Transfer Record/Lab Work Request

Received By
Date ____
Assigned to ____

Client ____
Client Contact ____
Phone ____

RFW Contact
Date Due ____
Project Number ____

SAMPLE IDENTIFICATION / **ANALYSES REQUESTED**

Sample No	Client ID No	Description	Matrix	Date Collected	Container/Preservative								

Matrix
S Soil
W Water
O Oil
DS Drum Solids
DL Drum Liquids
X Other

Special Instructions

Items/Reason	Relinquished By	Received By	Date	Time	Items/Reason	Relinquished By	Received By	Date	Time

RFW 21 21 001/A 3/86

Figure 8 1 Chain-of-Custody

9. REFERENCES

DOE 1986b "Comprehensive Environmental Assessment and Response Program Phase I Draft Installation Assessment Rocky Flats Plant," US Department of Energy unnumbered draft report, April 1986

DOE 1986f "Resource Conservation and Recovery Act Part B - Operating Permit Application for USDOE Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes," US Department of Energy unnumbered report, November 1986

Hurr 1976 R T Hurr, "Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado," US Geological Survey Open-File report 76-268, 1976

RI 1986a "Annual Environmental Monitoring Report January-December 1985," Rockwell International Rocky Flats Plant, Golden, Colorado report RFP-ENV-85, April 1986

RI 1986b "Rocky Flats Plant Radioecology and Airborne Pathway Summary Report," Rockwell International, Rocky Flats Plant, Golden, Colorado unnumbered report, December 1986

RI 1986c "Geological and Hydrological Data Summary, Rocky Flats Plant," Rockwell International, Rocky Flats Plant, Golden, Colorado unnumbered report, December 1986

APPENDIX 2

SOIL CHARACTERIZATION PLAN,
WEST SPRAY FIELD

SOIL CHARACTERIZATION PLAN
USDOE ROCKY FLATS PLANT
WEST SPRAY FIELD

OCTOBER 3, 1988

SUBMITTED TO:

ROCKWELL INTERNATIONAL
NORTH AMERICAN SPACE OPERATIONS
ROCKY FLATS PLANT
GOLDEN, COLORADO

PREPARED BY:

CHEN & ASSOCIATES, INC.
96 SOUTH ZUNI STREET
DENVER, COLORADO 80223

TABLE OF CONTENTS

FIGURE AND TABLE

1.0 INTRODUCTION

This sampling plan has been designed to characterize any chemical contamination of the soils at the West Spray Field and to provide an adequate data base for evaluating closure alternatives. The West Spray Field at the Rocky Flats Plant was first identified as a RCRA regulated unit in the fall of 1985 when the initial facility Part B application was in preparation. At that time, it was determined that certain waste streams being disposed at the West Spray Field were RCRA hazardous wastes. Shortly thereafter, it was determined that continued disposal of hazardous wastes at the West Spray Field would cease. Hence, a closure plan for interim status closure of the West Spray Field is required pursuant to Part 265 of the Colorado State Hazardous Waste Regulations (6 CCR) and Title 40, part 265 of the Code of Federal Regulations (40 CFR).

A closure plan was submitted on November 28, 1986, for the West Spray Field as part of the RCRA Post-Closure Care Permit Application for the Rocky Flats Plant (Rockwell International, 1986a). It was prepared in accordance with 6 CCR and 40 CFR 265. In February 1987, a report on 1986 characterization activities and proposed soil sampling plan was submitted to CDH and EPA regarding the West Spray Field. On January 5, 1988, a request for additional information was sent to the Department of Energy from the Colorado Department of Health. In partial fulfillment of that request, and based on meetings held between CDH, EPA, DOE and Rockwell International, additional soil samples will be collected and analyzed for a comprehensive suite of parameters in order to provide the basis for the West Spray Field closure requirements.

2.0 SITE BACKGROUND

2.1 Site History

The area was operated from April 1982 to October 1985. During operation, excess liquids from solar evaporation ponds 207B North and Center were pumped periodically to the West Spray Field for spray application. Based on interviews, direct application of the liquids occurred in portions of the spray field which have been designated Areas 1, 2 and 3 for the purpose of this report (Figure 2-1). Please see Section 1.1.3 of the Closure Plan for the additional historical information and a description of the spray application procedures.

The locations of the designated areas are supported by examination of aerial photographs. The photographs indicate some surface runoff occurred into the unnumbered areas within the approximate location of the spray field's exterior boundary. Limited quantities of windblown spray probably also contributed to the pattern observed on the aerial photographs.

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000294

Titled: WEST SPRAY FIELD, POINT OF COMPLIANCE MAP FIG 2-1

Fiche location: A-SW-M14

2.2 Source Characterization

Liquids applied in the West Spray Field were derived from solar evaporation ponds 207B North and Center. Approximately 67,000,000 gallons of wastewater were applied at the West Spray Field. Of this quantity approximately 10,000,000 gallons was taken from 207B North, and 57,000,000 gallons was taken from 207B Center.

The contents in Pond 207B North generally consist of liquid collected in the trench and french drain system located in the hillside north of the solar evaporation ponds. The interceptor system collected ground water and has historically controlled seepage from the solar ponds from entering North Walnut Creek. The liquid is pumped to Pond 207B North from the low point of the interceptor system, the interceptor trench pump house.

The liquid contained in Pond 207B Center generally consists of effluent from the Rocky Flats sanitary sewage treatment plant. However, some seepage collected in the interceptor trench system has also been placed in Pond 207B Center.

Sampling of the liquids from 207B North, 207B South, the interceptor trench pump house (ITPH) and the sewage treatment plant has taken place periodically from 1984 to 1988. The analytical data from the different sampling events is located in Table 1-4 in Section 1.2.10 of the West Spray Field Closure Plan.

The waste characterization summary (Section 1.2.10 of the West Spray Field Closure Plan) concludes that nitrate and uranium are the only constituents of the applied solar pond waters that were consistently and significantly elevated relative to the proposed ground-water concentration limits. Therefore, these constituents should be the best indicators of the soil (or ground water) contamination that may have resulted from application of water at the west spray field.

3.0 SOIL CHARACTERIZATION

3.1 Soil Types

Based on test pit logs from the 1988 sampling, the uppermost soil horizon at the West Spray Field ranges from 1.1 feet (WSF03, WSF06, WSF08, WSF09) to 1.35 feet (WSF04) in thickness. Plate 5-3 in Appendix 4 of the West Spray Field Closure Plan presents a fence diagram illustrating the soil zones within the test pits at the West Spray Field. This surface and upper part of the alluvial subsoil is described as dusky brown (5 YR 2/2) (Geological Society of America - Rock Color Chart, 1984) gravelly, cobbly, sandy clay or loam that is moist to wet. The zone is typically poorly to moderately sorted with subrounded and subangular fine-graded to coarse-graded (Grain Size Scale - American Geological Institute, 1982) gravels with occasional small cobbles. Sand is very fine-grained to trace medium-grained. Roots extend to about 0.9 feet. The contact into the next subsoil is wavy and sharp.

The next alluvial subsoil zone extends from 1.1 feet (WSF03, WSF06, WSF08, WSF09) to 3.5 feet in depth below ground surface (WSF01, WSF06, WSF07) (Plate 5-3, Appendix 4, West

Spray Field Closure Plan). This subsoil is a moderate brown (5 YR 4/4) gravelly, sandy clay to sandy clay and gravel with small zones of intense red and brown staining indicative of weathering. Sand is generally moderately sorted, subangular to subrounded, medium-grained to coarse-grained with occasional fine-grained pockets. Gravels are described as subrounded, fine-graded to very coarse-graded pebbles and small to large cobbles with occasional small boulders. The gravels and sands are indicative of a short transport distance. Clay occurs in the matrix but mostly in pockets associated with the gravel. The zone is generally moist to saturated. Some organic soil stringers from subsoil above were noted in WSF02, WSF03, WSF04, WSF05, and WSF06. The contact into the next subsoil is irregular and gradational and occurs from 3.0 feet to 3.5 feet in depth (Plate 5-3, Appendix 4, West Spray Field Closure Plan).

The lower zone extends from 2.5 feet (WSF03) to 5.2 feet (WSF01) in depth. This zone consists of sandy clay or clayey sand and gravel or gravelly sandy clay. Colors range from light brown (5 YR 5/6) to moderate yellowish brown (10 YR 5/4) with zones red, brown orange or yellow staining. The sand is typically medium-grained subangular to subrounded, moderately sorted, with some fine-grained and coarse-grained sands. Gravels are subrounded, moderately to poorly sorted, fine-grained pebbles to large cobbles with occasional small boulders. Clay zones of olive gray are commonly associated with the gravel and cobbles. The zone of olive gray are commonly associated with the gravel and cobbles. The zone is generally moist with occasional saturated zones. Caliche stringers were encountered at 4.4 feet in WSF06 just above a saturated zone.

3.2 Soil Testing performed to Date

Preliminary soil testing to evaluate whether the soils in the West Spray Field are contaminated and, if so, the level and extent of soil contamination has been conducted. Soil samples were collected during 1986 and 1988 to characterize the soil chemistry in the West Spray Field.

IN 1986, field investigations included soil samples to a depth of one foot from a plot in the West Spray Field (Figure 2-1 and Appendix 4, West Spray Field Closure Plan). In 1988, the sampling program consisted of digging 12 test pits (WSF01 to WSF12, Figure 2-1) with a backhoe and collecting three soil samples for chemical analyses from each location at varying depths (Appendix 4, West Spray Field Closure Plan).

The preliminary conclusions tentatively indicate that nitrate and volatile organic compounds are above estimated background concentrations in the West Spray Field soils. Levels of uranium, plutonium, and other radionuclides were found at levels typical of known or assumed background levels for the area. However, background soil and ground water at the Rocky Flats Plant in general, as well as the West Spray Field in particular, require additional characterization before the above statement can be adequately supported. A comprehensive plan for background characterization is under preparation. This plan will be implemented upon approval by CDH/EPA, and will yield data to conclusively determine whether or not the West Spray Field soils are contaminated. This plan will be submitted to CDH/EPA during calendar year 1988.

The soil sampling conducted to date in the West Spray Field provides a general idea of the types and levels of contamination which may be present in the West Spray Field soils. However, the information collected to date is not definitive enough to reach final conclusions because the background soil samples obtained in 1986 were taken to a maximum depth of one foot.

In addition, the 1986 sampling plot was not in an area of direct spray application. At the time of sampling, it was believed this area received application from the spray impulse canon in the West Spray Field. Additional information subsequent to sampling and testing indicated the sample area was only affected by surface runoff, and perhaps windblown spray from application in Area 1.

4.0 INDICATOR PARAMETERS

Soil samples will be obtained and tested in the laboratory for the following potential contaminants:

- Organics
  HSL-Volatiles (Table 4-1)
  Total Organic Carbon

- Radionuclides
  Plutonium 239
  Americium 241
  Uranium 233
  Uranium 234
  Uranium 238
  Strontium 90
  Tritium

- Other
  Nitrates
  Mercury
  Lead
  Percent Solids
  Volatile Solids

Geochemical properties obtained from this additional testing will be used to complete the characterization of the West Spray Field.

TABLE 4-1

CONTRACT LAB PROGRAMS (CLP)
VOLATILE ORGANIC COMPOUND
HAZARDOUS SUBSTANCE LIST (HSL)

Chloromethane	1,1,2,2-Tetrachloroethane
Bromomethane	1,2-Dichloropropane
Vinyl Chloride	Trans-1,3-Dichloropropene
Chloroethane	Trichloroethene
Methylene Chloride	Dibromochloromethane
Acetone	1,1,2-Trichloroethane
Carbon Disulfide	Benzene
1,1-Dichloroethene	Cis-1,3-Dichloropropene
1,1-Dichloroethane	2-Chloroethyl Vinyl Ether
Trans-1,2-Dichloroethene	Bromoform
Chloroform	4-Methyl-2-pentanone
1,2-Dichloroethane	2-Hexanone
2-Butanone	Tetrachloroethene
1,1,1-Trichloroethane	Toluene
Carbon Tetrachloride	Chlorobenzene
Vinyl Acetate	Ethyl Benzene
Bromodichloromethane	Styrene

Total Xylenes

5.0 SAMPLING METHODOLOGY

5.1 Location and Number of Sampling Points

The intent of the additional soil testing is to identify areas affected by liquid waste application and identify the affects of waste application on the soils. Within the West Spray Field, four areas have been identified for soil sampling. These areas are:

- o direct application Area 1;
- o direct application Area 2;
- o direct application Area 3; and
- o the areas which may have been subjected to runoff and overspray.

Twenty-four soil samples will be obtained in each of the four application areas from different sampling locations for geochemical analysis (Figure 2-1). The samples will be distributed in the vertical by obtaining a sample in each of the three major soil horizons described by the Soil Conservation Service (Section 3.1) and identified during field work. Samples will be obtained from each horizon to determine if the varying soil characteristics have accounted for different interactions with contaminants present in the applied waste. The exact test pit locations are presented in Figure 2-1. The sample locations have been biased toward those areas of visual contamination as observed in the aerial photographs (dated 1983 to 1986) in order to portray the extent of soil contamination. The sample locations portrayed on Figure 2-1 are either within the spray radius of the irrigation lines or are located in the gulleys/ditches observed in the aerial photographs. These samples, along with 1986 and 1988 sampling, will define levels of any contaminants in the West Spray Field. When combined with the 1988 samples, there will be a minimum of eight test pits in each of the three application areas in order to provide a statistical comparison of the data.

The sample locations should: 1) verify and characterize contaminant sources, 2) determine the present areal and vertical extent of soil contamination, and 3) support identification and technology assessments of alternative response actions for closure, including the "No Action" alternative. This soil sampling plan is designed to provide data on the level of soil contamination in the West Spray Field in order to evaluate the closure alternatives based on the closure performance standard.

5.2 Sample Collection Methods

This soil sampling plan follows the same soil sampling techniques utilized during the aforementioned 1988 sampling of the West Spray Field. These sampling techniques are described in the following sections.

Equipment Decontamination

All non-dedicated sampling equipment will be decontaminated prior to obtaining each sample. Decontamination procedures are outlined in Section 5.4. The effectiveness of the decontamination procedure will be evaluated by the analysis of field or rinsate blanks collected during sampling, as discussed in Section 10.1.

Field Analyses

For health and safety purposes (Section 9.0), one person on site will be designated the health and safety officer. That person will be in charge of monitoring the breathing zone in the pit with a photoionization detector prior to entry of sampling personnel. Section 9.0 designates the levels of protection required should readings above background be detected.

In addition, a direct radiation survey of the samples and the test pit walls will be conducted using a beta gamma detector. Areas delineated as above background in radiation levels in the pits will have soil sampling conducted as necessary to determine contaminate concentrations for evaluation of the closure plan alternatives.

All procedures for health and safety will conform to those specified in the U.S. Department of Energy Comprehensive Environmental Assessment and Response Program (CEARP) Phase 2: Installation Generic Monitoring Plan (IGMP) Health and Safety Plan. The IGMP Health and Safety Plan is presented in Appendix 5 of the West Spray Field Closure Plan.

Sample Collection

Test pits will be dug by a backhoe to approximate depths of five feet. Grab samples will be collected from each of the three exposed soil horizons (Section 3.0). Approximately four to six inches of soil will be scraped off the pit wall prior to obtaining a sample in order to ensure that the sample has not been contaminated by the backhoe by soil falling down from above or from smearing of soil along the face of the pit. The sample will be obtained using a decontaminated scoop or a trowel.

Sample Containers

Samples will be transferred directly from the sampling equipment to the sample containers. The sample containers will be precleaned according to EPA approved procedures. The type of sample container will be determined based on the analyses to be performed. The specific types of sample containers to be used are discussed in Section 6.0.

Sample Numbering System

Each sample collected for chemical analysis, including duplicates, field blanks and trip blanks will be identified by a unique sample identification number. Samples are identified by location prefix (West Spray Field-WSF), location identification (i.e., test pit number) and sample depth.

These data identifiers will be assigned prior to field activities. Field personnel will carry a list of designations, keyed to a map, into the field with them.

Additional locations may be assigned while field teams are on site, if warranted. If additional locations are assigned during field activities, they will be documented by the field team.

Field Quality Assurance/Quality Control

The field quality assurance/quality control program will follow procedures to be outlined in the January 1989 Quality Assurance/Quality Control Plan. It will include two basic areas: documentation of field activities (i.e., decontamination procedures, sampling techniques, unusual occurrences, preservation of samples and order in which samples were collected), and the routine collection and analysis of trip blanks and field (equipment) blanks. In addition:

- For all samples, the sample extraction implement will either be dedicated to the sample then disposed of, or thoroughly decontaminated prior to use on another sample.
- All sampling personnel will be required to avoid actions potentially causing cross contamination of sampling media (ex. dispose of boot covers or decontaminate boots between test pits).
- Sample extraction equipment will not be placed upon the ground or other potentially contaminated surfaces prior to use.
- On-site sample management will be meticulous in order to preserve the quality of the data.

5.3 Sampling

The following list of equipment is anticipated for the activities outlined in this sampling plan.

Survey Instruments

Hnu
Geiger-Mueller Ludlum Model 31 for measuring beta gamma radiation
35 mm camera/film

Protective Equipment

Tyvek suits
Box of inner gloves
Box of nitrile outer gloves
Ultra twin/canister mask
Organic vapor/dust cartridges or canisters
Rolls of duct tape
100-foot measuring tape
Boot covers

Sample Packaging Materials

8 ounce glass jars
40 ml VOA vials
1 liter cubitainers
500 ml bottles
4 ounce bottles
Bags vermiculite
Plastic bags
Rolls fiber tape
Boxes of garbage bags
Sets of cooler labels
Bags of ice
Coolers

Decontamination Equipment

Wash tubs
Orchard Sprayers
Box of "Alconox"
Pesticide grade hexane
Box of sanitizer (mask)
Laboratory rinse bottles
Waste solvent container
Assorted brushes
Distilled water
Deionized water
Paper towels
Garbage bags

Tap water
Polyethylene sheeting
Steam cleaner

Sampling Equipment

Watch
Backhoe
Nalgene disposable filters
Plastic or metal scoops
Shovel
Aluminum trays
Stainless steel buckets
Disposable nylon rope
Stakes and flagging

Documentation Materials

Site logbook
Chain-of-custody sheets
Preprinted sample jar labels
Preprinted field sheets
Receipt-for-samples form
Waterproof pens
Grease pencil

5.4 Field Decontamination

To reduce the potential for cross contamination occurring, the backhoe and all other pertinent sampling equipment should be decontaminated using a steam cleaner. The backhoe should be steam cleaned between test pit locations while all other sampling equipment will be decontaminated between sample locations unless they are disposable. However, due to the nature of the sampling activities, backhoe decontamination is not absolutely necessary between pit locations. In all cases, the backhoe will be used to remove soil to within a half foot of the proposed sample location and then a decontaminated shovel will be used to remove the remaining half foot. All sampling equipment shall be decontaminated upon arrival on site.

6.0 SAMPLE CONTAINERS, PRESERVATION AND HOLD TIMES

A comprehensive Quality Assurance/Quality Control Plan is being prepared by Rockwell International to address all sampling activities at the hazardous waste management units. The QA/QC document will include protocols for sample containers, sample preservation, and holding times.

7.0 SAMPLE CONTROL AND DOCUMENTATION

A comprehensive Quality Assurance/Quality Control Plan is being prepared by Rockwell International to address all sampling activities at the hazardous waste management units. The QA/QC document will be completed in January 1989. The plan will include methods for sample control and documentation.

All aspects of the sampling effort will be documented in various forms by sampling personnel. Documentation is required to assist laboratory personnel in identifying samples, aid in data collection and reporting, and to provide evidence on the validity of information gathered. One member of the sampling team will be assigned as the document coordinator and will be responsible for recording all information during sampling.

7.1 Logbook

All information pertinent to field activities will be recorded in bound, sequentially page numbered logbooks and will be written in with waterproof ink. The cover of the notebook will contain the following information: organization, address, book number, project name, start date and end date. The following information will be recorded prior to sampling and at each sampling location:

- Date and time of entry
- Brief objective of sampling
- Calibration information of field instrumentation
- Names of sampling personnel
- Sample location and proposed sampling methodology
- Results of field measurement (Hnu, beta gamma)
- Number and types of samples collected
- Date and time of sample collection
- Sequential sample ID number
- Field observations (weather, etc.)
- Signature of recorder at the end of the day

7.2 Chain-of-Custody Procedures

All samples will be collected and handled in accordance with the chain-of-custody procedures listed below:

- Samples will be kept in the possession or sight of at least one sampling team member at all times, unless transferred to a secure, locked area.
- A sample ID tag, including predesignated location ID and sample ID will be affixed in the field.
- Prior to relinquishing samples for packaging and shipment, one member of the sampling team will fill out a chain-of-custody record for all team members to sign.
- If samples are stored temporarily prior to shipment, they will be kept cool and placed in a secured storage area. Coolers will be sealed and custody seals affixed just prior to shipment.
- If custody is transferred to the Shipping and Receiving Department at Rocky Flats Plant, the recipient will sign the chain-of-custody form.
- Shipping receipt for shipment by courier will be retained and kept with one copy of the chain-of-custody form.

A photocopy of the signed Custody Record will be retained by the coordinator. The original chain-of-custody record will accompany the shipment to the laboratory.

7.3 Laboratory Custody Procedures

Upon arrival of the samples at the laboratory, laboratory personnel will sign and date receipt of the samples on the chain-of-custody record. Laboratory personnel will then be responsible for maintaining custody until time of analysis. The laboratory must be able to provide a locked and secured area.

8.0 SAMPLE HANDLING, TRANSPORT, AND STORAGE

Procedures for sample handling, transport and storage will conform to those specified in the U.S. Department of Energy Comprehensive Environmental Assessment and Response Program (CEARP) Phase 2: Installation Generic Monitoring Plan (IGMP) and Quality Assurance/Quality Control Procedures for Soil Characterization in Appendices 1 and 3, respectively in the closure plan.

A sample packaging/staging area location will be determined on a daily basis based upon proposed sample locations, visibility, safety and the facility's cooperation.

To minimize cross contamination between samples and to protect sampling and laboratory personnel from potential exposure to possible hazardous or radioactive contaminants, all samples will be decontaminated prior to packaging. At the sample staging location, sample containers and equipment will be washed on the exterior with a detergent, rinsed with tap water, and dried with paper towels. Decontamination solutions and rinse waters will be containerized and stored. After the sample analysis data are received and evaluated, appropriate disposal of these liquids will be determined.

Individual sample containers will be numbered sequentially using a white or colored grease pen to identify the sample number before sampling. Grease pens will be used to prevent loss of sample numbers during sampling. Often times, identifying marks on pre-labeled containers are lost during sample immersion in aqueous wastes or during decontamination. After samples have been decontaminated and dried, permanent gum labels or sample tags will be affixed to the sample containers. Permanent labels or tags will include the following information at a minimum:

- Exact location of the sample
- Time and date of sample collection
- Name of sampler and witnesses
- Sample sequential identification number (corresponding to that listed on the chain-of-custody record)
- Type of sample (grab or composite)
- Analyses requested
- Preservation methods (nitric acid, NaOH, $CuSO_4$, etc.)
- Destination (Lab name)
- Other pertinent information

All samples will be labeled, transported and/or stored according to standard U.S. EPA Region VIII procedures and Department of Transportation regulations as required in 49 CFR.

9.0 HEALTH AND SAFETY PLAN

Procedures for health and safety will conform to those specified in the U.S. Department of Energy Comprehensive Environmental Assessment and Response Program (CEARP) Phase 2: Installation Generic Monitoring Plan (IGMP) Health and Safety Plan. The IGMP Health and Safety Plan is presented in Appendix 5 of the West Spray Field closure plan. A specific health and safety plan will be prepared at least two months before sampling began and will be submitted to the Colorado Health Department for review. The Health and Safety Plan will also conform to the Rocky Flats Operational Safety Analysis (RFOSA) procedures, OSHA regulations, DOE orders and Rocky Flats Plant policies.

All field personnel will thoroughly review the site safety plan, understand the safety considerations and establish emergency procedures prior to site entry. All personnel must be subject to an active medical surveillance program and be authorized for use of respiratory protection.

Determination of appropriate level of protection should be made by surveillance with an Hnu photoionization detector. Levels of protection criteria are summarized below:

Level D	<5 ppm above off-site ambient and nuisance odors
Level C	5 ppm above off-site ambient
Level B	5 ppm to 20 ppm
Leave Site	>20 ppm

All measurements are to be in the breathing zone. All field personnel will have an air purifier respirator and dust cartridges on site as a precautionary measure.

The immediate hazard is skin contact with waste materials. Tyveks and boot covers should be worn for general body protection. Gloves (nitrile or better) should be worn during sample collection and handling. Standard minimum protective gear of steel-toed boots, hard hat, and safety glasses are required around the backhoe. Two-way radios will be on site for emergency use.

No eating, drinking, smoking or other hand-to-mouth activities will be allowed on site except in facility designated areas and after proper decontamination.

These standards are to be considered minimum; all of Rockwell International's guidelines will be adhered to and will supersede Chen's standards if they are more stringent.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

A comprehensive Quality Assurance/Quality Control Plan is being prepared by Rockwell International to address all sampling activities at the hazardous waste management units. The QA/QC document will be completed in January 1989. A number of quality control samples will be collected to ensure that all data produced are valid, defensible, and allow good comparison of the data. The plan will include the protocol for quality assurance and quality control to be followed by this sampling plan.

11.0 SCHEDULE

The schedule for implementing this sampling plan is presented in Section 1.6.3 of the West Spray Field closure plan. The sampling will be documented following completion of the January 1989 Quality Assurance/Quality Control Plan.

If required, because of changes in the closure plan, a revised soil sampling plan will be developed and submitted to CDH for their approval within 90 days after determining changes to the sampling plan are required. The revised soil sampling plan will be part of the revised closure plan.

12.0 REFERENCES

Aerial Photograph, 1986: Scharf & Associates, Flight No. 153.65, Photo No. 75005PB-1-1 to 75005PB-9-16, 5/21/86.

Rockwell, 1986: Rockwell International, July 28, 1986, "Radiation Monitoring Procedures Manual," Rockwell International, RMPM

Shirk, 1986: Shirk, K., September 15, 1986, personal communication.

U.S. Department of Agriculture, 1984: U.S. Department of Agriculture, 1984, "Soil Survey of Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties," unnumbered report.

USDOE, 1987a: U.S. Department of Energy, February, 1987, Comprehensive Environmental Assessment and Response Program, Phase 2: Rocky Flats Plant, Installation Generic Monitoring Plan (Comprehensive Source and Plume Characterization Plan), Health and Safety Plan.

USDOE, 1987b: U.S. Department of Energy, February, 1987, Comprehensive Environmental Assessment and Response Program, Phase 2: Rocky Flats Plant, Installation Generic Monitoring Plan (Comprehensive Source and Plume Characterization Plan), Sampling Plan.

USDOE, 1987c: U.S. Department of Energy, February, 1987, Comprehensive Environmental Assessment and Response Program, Phase 2: Rocky Flats Plant, Site-Specific Monitoring Plan (Work Plan for Performance of Remedial Investigations and Feasibility Studies for all High-Priority Sites), Quality Assurance/Quality Control Plan.

USEPA, 1987: U.S. Environmental Protection Agency, March, 1987, Data Quality Objectives for Remedial Response Activities, Development Process, EPA/540/G-87/003.

APPENDIX 3

QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES FOR SOIL CHARACTERIZATION

DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
ENVIRONMENT, SAFETY AND HEALTH DIVISION
ENVIRONMENTAL PROGRAMS BRANCH

COMPREHENSIVE ENVIRONMENTAL ASSESSMENT AND RESPONSE PROGRAM

PHASE 2:
ROCKY FLATS PLANT
SITE-SPECIFIC MONITORING PLAN

(Work Plan for Performance of Remedial Investigations and Feasibility Studies for all High-Priority Sites)

QUALITY ASSURANCE/QUALITY CONTROL PLAN

February 1987

DRAFT

INTRODUCTION

Quality assurance/quality control (QA/QC) for CEARP Phase 2b site characterizations (remedial investigations) at Rocky Flats Plant will be conducted following the procedures outlined in the CGMP and IGMP/CSPCP Quality Assurance/Quality Control Plans. Additional site-specific requirements have not been identified

The Quality Assurance/Quality Control Plan from the IGMP/CSPCP Monitoring Plan is included here as Appendix A

APPENDIX A

QUALITY ASSURANCE/QUALITY CONTROL PLAN

(Being Used in Its Entirety)

DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
ENVIRONMENT, SAFETY AND HEALTH DIVISION
ENVIRONMENTAL PROGRAMS BRANCH

COMPREHENSIVE ENVIRONMENTAL ASSESSMENT AND RESPONSE PROGRAM

PHASE 2:
ROCKY FLATS PLANT
INSTALLATION GENERIC MONITORING PLAN
(Comprehensive Source and Plume Characterization Plan)

QUALITY ASSURANCE/QUALITY CONTROL PLAN

February 1987

DRAFT

TABLE OF CONTENTS

TABLES

FIGURES

QUALITY ASSURANCE/QUALITY CONTROL PLAN

1. INTRODUCTION

CEARP Phase 2 consists of CEARP Phase 2a, Monitoring Plan, and CEARP Phase 2b, Site Characterization (Remedial Investigation) This Quality Assurance Quality Control (QA/QC) Plan is one component of the Monitoring Plan for Rocky Flats Plant The Monitoring Plan typically consists of five parts Synopsis, Sampling Plan, Technical Data Management Plan, Health and Safety Plan, and Quality Assurance/Quality Control Plan Because of the Compliance Agreement made by the State of Colorado, Environmental Protection Agency, and the DOE, this Monitoring Plan also includes a Feasibility Study Plan The Synopsis provides a discussion of the current situation and serves as an introduction to the other plans

CEARP uses a three-tiered approach in preparing the monitoring plans the CEARP Generic Monitoring Plan (CGMP) (DOE, 1986b), the Installation Generic Monitoring Plan (IGMP), and the Site-Specific Monitoring Plans (SSMPs) The CGMP Quality Assurance/Quality Control (QA/QC) Plan provides the generic guidelines and procedures that will be employed during CEARP Phase 2 site characterization (remedial investigation) to ensure the reliability of data collected at CEARP sites It is intended to establish a general quality assurance/quality control policy and to provide the framework for more specific quality assurance/quality control requirements to be employed at each installation and at each site This IGMP Quality Assurance/Quality Control Plan provides installation generic information and procedures whereas the SSMPs will provide site-specific detail regarding locations, types and number of samples

This IGMP is the Comprehensive Source and Plume Characterization Plan required by the Compliance Agreement Therefore, the acronym used to refer to this plan is IGMP/CSPCP

According to DOE policy, DOE activities shall maintain programs of quality assurance (DOE Order 5700 6B) In the area of environmental protection, quality assurance plans must be integrated with the DOE implementation of CERCLA (DOE Order 5480 14)

CEARP Phase 2b site characterizations (remedial investigations) will be implemented using procedures to assure that the precision, accuracy, completeness, and representativeness of data are known and documented At a minimum, this will include adherence to the CEARP CGMP, IGMP/CSPCP, and SSMP Quality Assurance/Quality Control Plans, and may include preparation of written Quality Assurance/Quality Control Plans covering each aspect of the project performed

This IGMP/CSPCP Quality Assurance/Quality Control Plan presents the organization, objectives, functional activities, and specific quality assurance and quality control activities associated with the CEARP Phase 2b site characterizations (remedial investigations) at Rocky Flats Plant. The Quality Assurance/Quality Control Plan is designed to achieve specific data quality goals for CEARP Phase 2b site characterizations (remedial investigations) Appendix A includes the quality assurance protocols for all laboratory services to be provided under CEARP Phase 2b site characterizations (remedial investigations)

A brief description of the CEARP Phase 2b site characterization (remedial investigation) and background can be found in the Synopsis. For a more in-depth background description, see the CEARP Phase 1 report

2. PROJECT ORGANIZATION AND RESPONSIBILITY

Project organization and responsibility are divided among DOE, Los Alamos National Laboratory, and Rockwell International as described below Los Alamos National Laboratory has the primary responsibility to implement CEARP under the guidance of DOE-Albuquerque Operations Office However, operational responsibilities have been assigned to Rockwell International at Rocky Flats Plant for the site characterizations (remedial investigations) The DOE-Rocky Flats Plant Area Office is responsible for the function of the Rocky Flats Plant Because of this responsibility, the DOE-Rocky Flats Plant Area Office will provide additional guidance to its contractor, Rockwell International, in implementation of the CEARP Phase 2b site characterizations (remedial investigations)

Project organization is shown in Figure 2 1 The responsibilities of the various personnel can be divided into operational, laboratory, and quality assurance responsibilities, as follows

2.1 OPERATIONAL RESPONSIBILITIES

Assistant Secretary for the Environment The DOE Assistant Secretary for the Environment appoints Headquarters investigation boards and establishes the scope of Headquarters investigations (DOE Order 5484 1) DOE-wide Environmental Surveys and Audits originate from the Assistant Secretary

Environmental Surveys and Audits Headquarters Environmental Survey Teams have been directed to conduct one-time environmental surveys and sampling of DOE facilities These surveys are independent of CEARP activities at Rocky Flats Plant, but data from survey team sampling will be utilized in the CEARP characterization of Rocky Flats Plant A Headquarters environmental survey team visited the Rocky Flats Plant site in 1986 The results of the survey will be used as an internal management tool by the Secretary and Undersecretary of DOE

Audits are a function of the Office of the Assistant Secretary for the Environment Audit teams provide quality control for the implementation of environmental monitoring at DOE facilities Although independent of CEARP, audit teams complement CEARP activities by providing additional quality assurance

DOE-Albuquerque Operations Office Environmental Programs Branch The DOE-Albuquerque Operations Office, Environmental Programs Branch, is responsible for overseeing all environmental programs within DOE-Albuquerque Operations and conducting special assessments such as CEARP

DOE-Rocky Flats Area Office The DOE Rocky Flats Area Office is responsible for the missions of the Rocky Flats Plant, including environmental protection The DOE Rocky Flats Area Office oversees the integration of Rocky Flats Plant resources with CEARP activities at Rocky Flats Plant

Rockwell International Rockwell International, as prime contractor to DOE, provides support to DOE in accomplishing the mission of Rocky Flats Plant, including environmental protection Rockwell International will perform the CEARP Phase 2b site characterizations (remedial investigations) at Rocky Flats Plant

Los Alamos National Laboratory Los Alamos National Laboratory manages the CEARP program, providing direction, oversight and review, and preparing final reports

2.2. ANALYTICAL LABORATORY RESPONSIBILITIES

Analytical laboratory responsibilities include performing analytical services, and providing quality assurance Rockwell International will perform the CEARP Phase 2b site characterizations (remedial investigations) at Rocky Flats Plant This IGMP/CSPCP provides guidance for quality assurance programs to be implemented by

- field laboratory operations
- analytical laboratories
- geotechnical laboratories
- radiological laboratories

2.3. QA RESPONSIBILITY

Quality assurance responsibilities are to monitor and review the procedures used to perform all aspects of site characterizations (remedial investigations), including data collection, analytical services, data analysis, and report preparations Primary responsibility for project quality rests with the Rockwell International CEARP Manager Ultimate responsibility for project quality rests with DOE

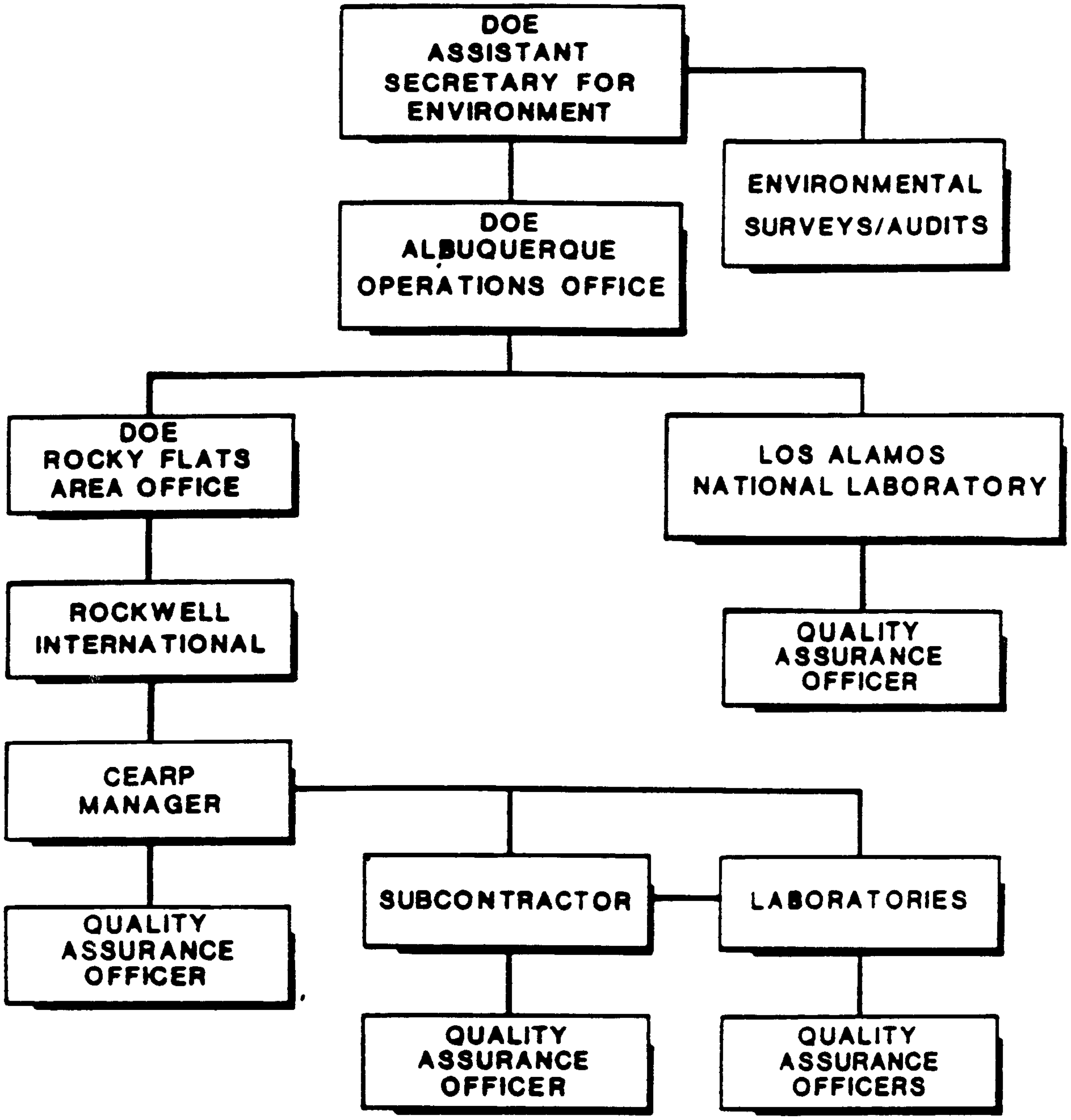


Figure 2 1 Quality Assurance/Quality Control Organization Chart

3 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall quality assurance objective is to develop and implement procedures for field sampling, field testing, chain of custody, laboratory analysis, and reporting that will assure quality as specified in DOE orders governing quality assurance and environmental protection Specific procedures to be used for sampling, chain-of-custody, audits, preventive maintenance, and corrective actions are described in other sections of this IGMP Quality Assurance/Quality Control Plan The purpose of this section is to define quality assurance goals for accuracy, precision and sensitivity of analysis, and completeness, representativeness, and comparability of measurement data from all analytical laboratories Quality assurance objectives for field measurements are also discussed

For some field activities, samples will not be collected, but measurements will be taken where quality assurance concerns are appropriate (e g, field measurements of pH, temperature, and elevations) The primary quality assurance objective in activities where samples are not collected is to obtain reproducible measurements to a degree of accuracy consistent with their intended use and to document measurement procedures

3.1 REGULATORY AND LEGAL REQUIREMENTS

Data used to evaluate compliance with the National Interim Primary Drinking Water Standards, State of Colorado water-quality standards, or water-quality criteria for agricultural or industrial use will have method detection limits as specified by the analytical method used, as appropriate

3 2 LEVEL OF QUALITY ASSURANCE EFFORT

Field duplicates, field blanks, and trip blanks will be taken and submitted to the analytical laboratories to provide a means to assess data quality resulting from field sampling Duplicate samples will be analyzed to check for sampling reproducibility Field and trip blanks will be analyzed to check for procedural contamination and/or ambient site conditions that are causing sample contamination Trip blanks will be analyzed to check for contamination during packaging and shipment

Because volatile organic compounds are a class of contaminants most likely to be introduced to the sample by the sample container, there will be one trip blank per batch of samples designated for volatile organic compound analysis (shipping container) There will be one duplicate and one field blank for every 10 investigative samples collected For laboratory organic analysis, matrix spikes and matrix spike duplicates will be used The general level of quality assurance effort for organic analysis will be one matrix spike and one matrix spike duplicate prepared for every 20 samples of similar concentration and/or similar sample matrix, whichever is greater In addition to field check samples, water samples of known concentration traceable to either EPA or NBS standards will be prepared for inorganic and radiological analyses. The general level of quality assurance effort for inorganic analyses will be one duplicate known sample and one duplicate field sample for every 10 investigative samples to check analytical reproducibility

Soil samples selected for geotechnical testing will include one field duplicate for each 20 analyses being performed, if possible, but will not include blanks

The groundwater, surface water, and soil samples collected at Rocky Flats Plant during CEARP Phase 2 will be analyzed using the analytical methods specified in Tables 3 1, 3 2, 3 3, and 3 4 The level of laboratory quality assurance effort will correspond to the procedures outlined in Appendix A.

3.3 ACCURACY, PRECISION, AND SENSITIVITY OF ANALYSES

The fundamental quality assurance objective with respect to accuracy, precision, and sensitivity of laboratory analytical data is to achieve the quality control acceptance criteria of the analytical protocols Sensitivities required for analyses of radionuclides, organics, metals, and other inorganic compounds, in both aqueous and solid matrices will be the detection limits shown in Tables 3 1, 3 2, 3 3, 3 4, 3 5, and 3 6 Achieving these detection limits depends on the sample matrix Highly contaminated samples requiring dilution will have detection limits higher than those detected

The accuracy of field laboratory measurements of groundwater and surface water pH will be assessed through pre-measurement calibrations and post-measurement verifications using at least two standard buffer solutions The two measurements must each be within +0 05 standard units of buffer solution values Precision will be assessed through replicate measurements of every tenth sample The standard deviation of four replicate measurements must be less than or equal to 0 1 standard units (The electrode will be withdrawn, deionized-rinsed and re-immersed between each replicate The calibration and verification will be done before the first replicate and after the last replicate) The instrument used will be capable of providing measurements to 0 01 standard units

The geotechnical and field data will be considered accurate if the quality assurance criteria with respect to equipment, solutions, and calculations are met, and if adherence to appropriate methods can be documented during a systems audit

3.4 COMPLETENESS, REPRESENTATIVENESS AND COMPARABILITY

The laboratories will provide data meeting quality control acceptance criteria as described in Appendix A Laboratories will provide completely valid data (IGMP/CSPCP QA/QC Plan, Section 8), the reasons for any variances from 100 percent completeness will be documented in writing.

3 5 FIELD MEASUREMENTS

Measurement data will be generated in many field activities. These activities may include, but are not limited to, the following

- using geophysical surveys
- documenting time and weather conditions
- locating and determining the elevation of sampling stations
- measuring pH, conductivity, and temperature of water samples
- qualitative organic vapor screening of solid samples using a photoionization detector (PID) or an organic vapor analyzer (OVA)
- measuring water levels in a borehole or well
- standard penetration testing
- calculating pumping rates
- verifying well-development and presampling purge volumes
- performing hydraulic conductivity tests

The general quality assurance objective for such measurement data is to obtain reproducible and comparable measurements to a degree of accuracy consistent with the intended use of the data through the documented use of standardized procedures Procedures for performing these activities and standardized formats for documenting them are presented in the CGMP and IGMP/CSPCP Sampling Plans. These procedures may be incorporated by reference (EPA methods) or included as appendices Standardized formats for documenting data collection are included in the Technical Data Management Plan

Table 3 1 Analysis Plan for Aqueous Samples*

Analyte	Method	Detection Limit	Sample Container	Sample Volume	Preservations	Holding Time (days)	Reporting Units
HSL Volatile	Ref 1	X[3]	40 ml vial (2) w/teflon lined silicone rubber septum	40 ml	Cold, 4°C[9]	14	ug/L
HSL Base/Neutral/Acid[1]	Ref. 2	X[3]	Amber G, 1L	1 L	Cold, 4°C[9]	7/40[7]	ug/L
HSL Pesticide/PCB	Ref 3	X[3]	Amber G, 1L	1 L	Cold, 4°C[9]	7/40	ug/L
HSL Inorganic[2]	EPA 200 7[8]	X[3]	P, G, 1L	1 L	pH<2, w/HNO_3[9]	180	ug/L
Cyanide	EPA 335[8]	X[3]	P, G, 1L	0 5 L	pH>11, w/NaOH[9]	14	ug/L
pH[4]	EPA 150 1[8]	0 1 pH unit	P, G	N/A	None	Field Meas	pH unit
Sp Conductivity[4]	EPA 120 1[8]	1	P, G	N/A	None	Field Meas	umho/cm
Temperature[4]	EPA 170 1[8]	0 1	P, G	N/A	None	Field Meas	°C
Diss Oxygen[4]	EPA 360 1[8]	0 5	G	N/A	None	Field Meas	mg/l
TDS	EPA 160[8]	5	P, G 1L	0 1 L	Cold 4°C[9]	7	mg/l
TSS	EPA 160[8]	10	P, G 1L	0 1 L	Cold 4°C[9]	7	mg/l
Total Phosphate	EPA 365 4[8]	0 01	P, G 1L	1 L	Cold 4°C, pH<2[9] w/H_2SO_4	28	mg/l

Table 3.1 (Continued)

Analyte	Method	Detection Limit	Sample Container	Sample Volume	Preservations	Holding Time (days)	Reporting Units
Chloride, Sulfate	EPA 352 2[8] 375 2[8]	5	P, G, 1L	1 L	Cold 4°C[9]	28	mg/l
Carbonate/Biocarbonate[5]	S M 403[6]	10	P, G, 1L	1 L	Cold 4°C[9]	14	mg/l
Nitrate	EPA 300 0[8]	5	P, G, 1L	1 L	Cold 4°C[9]	2	mg/l
Hexavalent Chromium	S M 312B[6]	0 01	P, G, 1L	1 L	Cold 4°C[9]	1	mg/l

[1] The HSL Base/Neutral/Acid fractions analytical parameters are the HSL semivolatites.
[2] Includes Cesium, Molybdenum, Strontium which are non HSL metals.
[3] See Tables 3 5 and 3 6
[4] Field Measurements
[5] These are reported as carbonate and biocarbonate alkalinity
[6] Standard Methods for Examination of Water and Wastewater, 15th Edition
[7] 7 days to extraction, analysis within 40 days of extraction
[8] Methods for Chemical Analysis of Water and Wastes, 1983, EPA 600/4 79 020
[9] All samples with the exception of VOA's will be filtered within 4 hours of sample collection, and preservatives added to the filtrate as specified All samples will be kept at 4°C until delivered to the laboratory
*The SSMP Sampling Plans will define the actual suite of parameters to be analyzed for specific samples

Method References

Ref 1 Method 624 "Methods for Organic Chemical Analysis of Municipal and Industrial Waste Water," EPA 600/4 82 057 plus additions, 1984

Ref 2 Method 625 "Methods for Organic Chemical Analysis of Municipal and Industrial Waste Water," EPA 600/4 82 057 plus additions, 1984

Ref 3 Method 608 "Methods for Organic Chemical Analysis of Municipal and Industrial Waste Water," EPA 600/4 82 057 plus additions, 1984

Table 3.2. Analysis Plan for Soil/Sediment/Waste Samples[a]

Analyte	Method	Detection Limit	Sample Container	Sample Volume	Preservations	Holding Time (days)	Reporting Units
HSL Volatile	Ref 2	x^2	40 ml vial (2) w/teflon lined silicon rubber septa	5	Cold, 4°C	14	ug/kg
HSL Base/Neutral/Acid	Ref 3	x^2	Amber G, 1 l	10 30	Cold, 4°C	7/40[3]	ug/kg
HSL Pesticide/PCB	Ref 4	x^2	Amber G, 1 L	10 30	Cold, 4°C	7/40[3]	ug/kg
HSL Inorganic[1]	Ref 5	x^2	P G, 1 L	200	Cold, 4°C	180	mg/kg
Reactivity	Ref 6	Ref 8	Amber G		Cold 4°C	N/A	ug/l
EP Toxicity	Ref 7	Ref 9	Amber G	100 g	Cold 4°C	N/A	ug/l in leachate
Chloride	EPA 300 0[5]	60 ug/g[6]	G, 1 L	20	Cold, 4°C	N/A	mg/kg
Sulfate	EPA 300 0[5]	60 ug/g[6]	G, 1 L	20	Cold, 4°C	N/A	mg/kg
Nitrate	EPA 300 0[5]	60 ug/g[6]	G, 1 L	20	Cold, 4°C	N/A	mg/kg
Cyanide	Ref 1	x^2	G, 1 L	200	Cold, 4°C	14	mg/kg
Hexavalent Chromium	S M 312B[7]	1 ug/g[6]	G, 1 L	100	Cold 4°C	1	mg/kg

[1] Includes Cesium, Molybdenum, and Strontium which are non HSL metals

[2] See Tables 3 5 and 3 6

[3] Extract within 7 days, analysis within 40 days of extraction

[4] Reported as dry weight, % moisture reported separately

[5] Soil/Sediments will be leached with Laboratory Reagent Water (20 g soil to 50 ml water) and water extract analyzed using referenced procedure Procedure reference Methods for Chemical Analysis of Water and Wastes, 1983, EPA 600/4 79 020

Table 3 2 (Continued)

[6] These are estimated detection limits

[7] Soil/sediment will be leached with Laboratory Reagent Water (5 g soil and 100 ml of water) by shaking for 2 hours, and the water extract filtered and subsequently analyzed This is in accordance with method 312B in Standard Methods for Examination of Water and Wastewater, 15th Edition

*The SSMP Sampling Plans will define the actual suite of parameters to be analyzed for specific samples

Method References

Ref 1 Method 9010 "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984

Ref 2 Method 8240 "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984

Ref 3 Method 8270 "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984

Ref 4 Method 8080 "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984

Ref 5 Method 6010 or 7000 Series Methods "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984

Ref 6 Method 9010, 9030 "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984

Ref 7 Method 1310 "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984

Table 3 3 Analysis Plan for Radiological Analysis for Aqueous Samples

Analyte	Method*	Detection Limit**	Sample Container	Sample Volume	Preservations	Holding Time (days)	Reporting Units
Gross alpha/beta	1,2,3,4,6,7, 8,9	Gross a = 2pCi/L	P, 1 gal	0 2 L	HNO_3 to pH <2	180	pCi/L
Tritium	1,2,3,8	400 pCi/L	G, 100 ml	0 008 L	No preservation	NA	pCi/L
Pu 239	10,11	0 3 pCi/L	P, 1 gal	1 000 L	HNO_3 to pH <2	180	pCi/L
Am 241	11,12	0 4 pCi/L	P, 1 gal	1 000 L	HNO_3 to pH <2	180	pCi/L
Isotopic U	1,3,4,7,8,9	U 233 + 234 = 0 6 pCi/L U 238 = 0 6 pCi/L	P, 1 gal	0 500 L	HNO_3 to pH <2	180	pCi/L
Sr 90	1,3,4,8	1 pCi/L	P, 1 gal	1.000 L	HNO_3 to pH <2	180	pCi/L

*See Attachment 1
**See Attachment 2

ATTACHMENT 1

Method References

1 U S Environmental Protection Agency, 1979, Radiochemical Analytical Procedures for Analysis of Environmental Samples, Report No EMSL-LY-0539-1, Las Vegas, NV, U S Environmental Protection Agency

2 American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985 Standard Methods for the Examination of Water and Wastewater, 16th ed., Washington, D C, Am Public Health Association

3 U S Environmental Protection Agency, 1976 Interim Radiochemical Methodology for Drinking Water, Report No EPA-600/4-75-008 Cincinnati U S Environmental Protection Agency

4 Harley, J H, ed, 1975, HASL Procedures Manual, HASL-300, Washington, D C, U S Energy Research and Development Administration

5 Misaqi, Fazlelleh L, Monitoring Radon-222 Content of Mine Waters Informational Report 1026, U S Department of Interior, Mining Enforcement and Safety Administration, Denver, CO, 1975

6 "Radioassay Procedures for Environmental Samples," 1967, USDHEW, Section 7 2 3

7 "Handbook of Analytical Procedures," USAEC, Grand Junction Lab 1970, page 196

8 "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, Auguat 1980, Environmental Monitoring and Support Laboratory, Office of Research and Development, U S Environmental Protection Agency, Cincinnati, Ohio 45268

9 "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments," U S G S Book 5, Chapter A5, 1977

10 "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U S EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979

11 "Procedures for the Isolation of Alpha Spectrometrically Pure Plutonium, Uranium and Americium," by E H Essington and B J Drennon, Los Alamos National Laboratory, a private communication

12 "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories

ATTACHMENT 2

Lower Limits of Detection

The detection limits presented were calculated using the formula in N R C Regulatory Guide 4 14, Appendix Lower Limit of Detection, pg 21, and follow

$$LLD = \frac{4.66 \left(\frac{BKG}{DUR}\right)^{1/2}}{(2.22)\ (Eff)\ (CR)\ (SR)\ (e\text{-}xt)\ (Aliq)},$$

Where

LLD	=	Lower Limit of Detection in pCi per sample unit
BKG	=	Instrument Background in counts per minute (cpm)
DUR	=	Duration of sample counting in minutes
Eff	=	Counting efficiency in cpm/disintegration per minute (dpm)
CR	=	Fractional radiochemical yield
SR	=	Fractional radiochemical yield of a known solution
x	=	The radioactive decay constant for the particular radionuclide
t	=	the elapsed time between sample collection and counting

In that LLD is a function of many variables including sample matrix, sample volume, and other factors, the limits presented are only intended as guides to order-of-magnitude sensitivities and, in practice, can easily change by a factor of two or more even for the conditions specified

Table 3 4 Analysis Plan for Radiological Analysis for Soils/Sediments

Analyte	Method*	Detection Limit**	Sample Container	Sample Size (g)	Preservations	Holding Time (days)	Reporting Units
Gross alpha/beta	1,2,3,4,6,7, 8,9	Gross a = 4 pCi/g Gross b = 10 pCi/g	G, 1 L	0 1	NA	NA	pCi/g
Pu 239	10,11	0 3 pCi/g	G, 1 L	1	NA	NA	pCi/g
Am 241	11,12	0 3 pCi/g	G, 1 L	1	NA	NA	pCi/g
Isotopic U	1,3,4,7,8,9	U 233 + 234 = 0 3 pCi/g U 238 = 0 3 pCi/g	G, 1 L	1	NA	NA	pCi/g
Sr 90	1,3,4,8	1 pCi/g	G, 1 L	1	NA	NA	Pci/g

*See Attachment 1
**See Attachment 2

ATTACHMENT 1

Method References

1 U S Environmental Protection Agency, 1979, Radiochemical Analytical Procedures for Analysis of Environmental Samples, Report No EMSL-LY-0539-1, Las Vegas, NV, U S Environmental Protection Agency

2 American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985 Standard Methods for the Examination of Water and Wastewater, 16th ed., Washington, D C., Am. Public Health Association

3 U S Environmental Protection Agency, 1976 Interim Radiochemical Methodology for Drinking Water, Report No EPA-600/4-75-008 Cincinnati U S Environmental Protection Agency

4 Harley, J H, ed, 1975, HASL Procedures Manual, HASL-300, Washington, D C, U S Energy Research and Development Administration

5 Misaqi, Fazlelleh L, Monitoring Radon-222 Content of Mine Waters Informational Report 1026, U S Department of Interior, Mining Enforcement and Safety Administration, Denver, CO, 1975.

6 "Radioassay Procedures for Environmental Samples," 1967, USDHEW, Section 7 2 3

7 "Handbook of Analytical Procedures," USAEC, Grand Junction Lab 1970, page 196

8 "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, Auguat 1980, Environmental Monitoring and Support Laboratory, Office of Research and Development, U S Environmental Protection Agency, Cincinnati, Ohio 45268

9 "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments," U S G S Book 5, Chapter A5, 1977

10 "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U S EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979

11 "Procedures for the Isolation of Alpha Spectrometrically Pure Plutonium, Uranium and Americium," by E H Essington and B J Drennon, Los Alamos National Laboratory, a private communication.

12 "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories

ATTACHMENT 2

Lower Limits of Detection

The detection limits presented were calculated using the formula in NRC Regulatory Guide 4 14, Appendix Lower Limit of Detection, pg 21, and follow

$$LLD = \frac{4.66 \left(\frac{BKG}{DUR}\right)^{1/2}}{(2.22)\,(Eff)\,(CR)\,(SR)\,(e^{-\lambda t})\,(Aliq)},$$

Where

LLD	=	Lower Limit of Detection in pCi per sample unit
BKG	=	Instrument Background in counts per minute (cpm)
DUR	=	Duration of sample counting in minutes
Eff	=	Counting efficiency in cpm/disintegration per minute (dpm)
CR	=	Fractional radiochemical yield
SR	=	Fractional radiochemical yield of a known solution
λ	=	The radioactive decay constant for the particular radionuclide
t	=	the elapsed time between sample collection and counting

In that LLD is a function of many variables including sample matrix, sample volume, and other factors, the limits presented are only intended as guides to order-of-magnitude sensitivities and, in practice, can easily change by a factor of two or more even for the conditions specified

Table 3 5 Hazardous Substance List (HSL) and Contract Required Detection Limits (CRDL)**

Volatiles	CAS Number	Detection Limits* Low Water[a] ug/L	Low Soil/Sediment[b] ug/Kg
1 Chloromethane	74-87-3	10	10
2 Bromomethane	74-83-9	10	10
3 Vinyl Chloride	75-01-4	10	10
4 Chloroethane	75-00-3	10	10
5 Methylene Chloride	75-09-2	6	5
6 Acetone	67-64-1	10	10
7 Carbon Disulfide	75-15-01	5	5
8 1,1-Dichloroethene	75-35-4	5	5
9 1,1-Dichloroethane	75-35-3	5	5
10 trans-1,2-Dichloroethene	156-60-5	5	5
11 Chloroform	67-66-3	5	5
12 1,2-Dichloroethane	107-06-2	5	5
13 2-Butanone	78-93-3	10	10
14 1,1,1-Trichloroethane	71-55-6	5	5
15 Carbon Tetrachloride	56-23-5	5	5
16 Vinyl Acetate	108-05-4	10	10
17 Bromodichloromethane	75-27-4	5	5
18 1,1,2,2-Tetrachloroethane	79-34-5	5	5
19 1,2-Dichloropropane	78-87-5	5	5
20 trans-1,3-Dichloropropene	100061-02-6	5	5
21 Trichloroethene	79-01-6	5	5
22 Dibromochloromethane	124-48-1	5	5
23 1,1,2-Trichloroethane	79-00-5	5	5
24 Benzene	71-43-2	5	5
25 cis-1,3-Dichloropropene	10061-01-5	5	5
26 2-Chloroethyl Vinyl Ether	110-75-8	10	10
27 Bromoform	75-25-2	5	5
28 2-Hexanone	591-78-6	10	10
29 4-Methyl-2-pentanone	108-10-1	10	10
30 Tetrachloroethene	127-18-4	5	5
31 Toluene	108-88-3	5	5
32 Chlorobenzene	108-90-7	5	5
33 Ethyl Benzene	100-41-4	5	5
34 Styrene	100-42-5	5	5
35 Total Xylenes	100-42-5	5	5

Table 3 5 (Continued)

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
36 N-Nitrosodimethylamine	62-75-9	10	330
37 Phenol	108-95-2	10	330
38 Aniline	62-53-3	10	330
39 bis(2-Chloroethyl) ether	111-44-4	10	330
40 2-Chlorophenol	95-57-8	10	330
41 1,3-Dichlorobenzene	541-73-1	10	330
42 1,4-Dichlorobenzene	106-46-7	10	330
43 Benzyl Alcohol	100-51-6	10	330
44 1,2-Dichlorobenzene	95-50-1	10	330
45 2-Methylphenol	95-48-7	10	330
46 bis(2-Chloroisopropyl ether	39638-32-9	10	330
47 4-Methylphenol	106-44-5	10	330
48 N-Nitroso-Dipropylamine	621-64-7	10	330
49 Hexachloroethane	67-72-1	10	330
50 Nitrobenzene	98-95-3	10	330
51 Isophorone	78-59-1	10	330
52 2-Nitrophenol	88-75-5	10	330
53 2,4-Dimethylphenol	105-67-9	10	330
54 Benzoic Acid	65-85-0	50	1600
55 bis(2-Chloroethoxy) methane	111-91-1	10	330
56 2,4-Dichlorophenol	120-83-2	10	330
57 1,2,4-Trichlorobenzene	120-82-1	10	330
58 Naphthalene	91-20-1	10	330
59 4-Chloroaniline	106-47-8	10	330
60 Hexachlorobutadiene	87-68-3	10	330
61 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
62 2-Methylnaphthalene	91-57-6	10	330
63 Hexachlorocyclopentadiene	77-47-4	10	330
64 2,4,6-Trichlorophenol	88-06-2	10	330
65 2,4,5-Trichlorophenol	95-95-4	50	1600
66 2-Chloronaphthalene	91-58-7	10	330
67 2-Nitroaniline	88-74-4	50	1600
68 Dimethyl Phthalate	131-11-3	10	330
69 Acenaphthylene	208-96-8	10	330
70 3-Nitroaniline	99-09-2	50	1600

Table 3 5 (Continued)

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
71 Acenaphthene	83-32-9	10	330
72 2,4-Dinitrophenol	51-28-5	50	1600
73 4-Nitrophenol	100-02-7	50	1600
74 Dibenzofuran	132-64-9	10	330
75 2,4-Dinitrotoluene	121-14-2	10	330
76 2,6-Dinitrotuluene	606-20-2	10	330
77 Diethylphthalate	84-66-2	10	330
78 4-Chlorophenyl Phenyl ether	7005-72-3	10	330
79 Fluorene	86-73-7	10	330
80 4-Nitroaniline	100-01-6	50	1600
81 4,6-Dinitro-2-methyl-phenol	534-52-1	50	1600
82 N-nitrosodiphenylamine	86-30-6	10	330
83 4-Bromophenyl Phenyl ether	101-55-3	10	330
84 Hexachlorobenzene	118-74-1	10	330
85 Pentachloropphenol	87-86-5	50	1600
86 Phenanthrene	85-01-8	10	330
87 Anthracene	120-12-7	10	330
88 Di-n-butylphthalate	84-74-2	10	330
89 Fluoranthene	206-44-0	10	330
90 Benzidine	92-87-5	50	1600
91 Pyrene	129-00-0	10	330
92 Butyl Benzyl Phthalate	85-68-7	10	330
93 3,3'-Dichlorobenzidine	91-94-1	20	660
94 Benzo(a)anthracene	56-55-3	10	330
95 bis(2-ethylhexyl) phthalate	117-81-7	10	330
96 Chrysene	218-01-9	10	330
97 Di-n-octyl Phthalate	117-84-0	10	330
98 Benzo(b)fluoranthene	205-99-2	10	330
99 Benzo(k)fluoranthene	207-08-9	10	330
100 Benzo(a)pyrene	50-32-8	10	330
101 Indeno(1,2,3-cd)pyrene	193-39-5	10	330
102 Dibenz(a,h)anthracene	53-70-3	10	330
103 Benzo(g,h,i)perylene	191-24-2	10	330

Table 3 5 (Continued)

Pesticides	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[f] ug/Kg
104 alpha-BHC	319-84-6	0 05	8 0
105 beta-BHC	319-85-7	0 05	8 0
106 delta-BHC	319-86-8	0 05	8 0
107 gamma-BHC (Lindane)	58-89-9	0 05	8 0
108 Heptachlor	76-44-8	0 05	8 0
109 Aldrin	309-00-2	0 05	8 0
110 Heptachlor Epoxide	1024-57-3	0 05	8 0
111 Endosulfan I	959-98-8	0 05	8 0
112 Dieldrin	60-57-1	0 10	16 0
113 4,4'-DOE	72-55-9	0 10	16 0
114 Endrin	72-20-8	0 10	16 0
115 Endosulfan II	33213-65-9	0.10	16 0
116 4,4'-DDD	72-54-8	0 10	16 0
117 Endrin Aldehyde	7421-93-4	0.10	16 0
118 Endosulfan Sulfate	1031-07-8	0.10	16 0
119 4,4-'DDT	50-29-3	0.10	16 0
120 Endrin Ketone	53494-70-5	0 10	16 0
121 Methoxychlor	72-43-5	0.5	80 0
122 Chlordane	57-74-9	0 5	80 0
123 Toxaphene	8001-35-2	1 0	160 0
124 AROCLOR-1016	12674-11-2	0 5	80 0
125 AROCLOR-1221	11104-28-2	0 5	80 0
126 AROCLOR-1232	11141-16-5	0 5	80 0
127 AROCLOR-1242	53469-21-9	0 5	80 0
128 AROCLOR-1248	12672-29-6	0 5	80 0
129 AROCLOR-1254	11097-69-1	1 0	160 0
130 AROCLOR-1260	11096-82-5	1 0	160 0

[a]Medium Water Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Water CRDL

[b]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Soil/Sediment CRDL

[c]Medium Water Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 100 times the individual Low Water CRDL

[d]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 60 times the individual Low Soil/Sediment CRDL

Table 3 5 (Continued)

[e]Medium Water Contract Required Detection Limits (CRDL) for Pesticide HSL Compounds are 100 times the individual Low Water CRDL
[f]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Pesticide HSL compounds are 60 times the individual Low Soil/Sediment CRDL

*Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, as required by the contract, will be higher

**These are the EPA detection limits under the Contract Laboratory Program Specific detection limits are highly matrix dependent The detection limits listed herein are provided for guidance and may not always be achievable

Table 3 6 Elements Determined by Inductively Coupled Plasma Emission or Atomic Absorption Spectroscopy

Element	Contract Required Detection Level[1,2] (ug/L)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Cesium	200
Molybdenum	40
Strontium	200
Cyanide	10

Note Detection limits in soil/sediment are numerically equivalent to those listed above with concentration units of mg/kg

[1] Higher detection levels may also be used in the following circumstances

If the sample concentration exceeds two times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the contract required detection limit. This is illustrated in the example below

Table 3 6 (Continued)

For lead

Method in use - ICP
Instrument Detection Limit (IDL) = 40
Sample Concentration = 85
Contract Required Detection Limit (CRDL) = 5

The value of 85 may be reported even though instrument detection limit is greater than required detection level The instrument or method detection limit must be documented

[2]These CRDL are the instrument detection limits obtained in pure water met using the procedure in Exhibit E The detection limits for samples may be considerably higher depending on the sample matrix

4 SAMPLING PROCEDURES

Procedures for collecting samples and for performing all related field activities are described in detail in Appendix A of the IGMP/CSPCP Sampling Plan Adherence to these procedures will be confirmed by the CEARP Quality Assurance Officers (Rockwell International and subcontractor) by quality assurance audits

5. SAMPLE CUSTODY

CEARP field custody procedures are described in Section 7 2 of the IGMP/CSPCP Sampling Plan Laboratory custody procedures for the analytical laboratories are described in Appendix A

6 CALIBRATION PROCEDURES AND FREQUENCY

Standard commercial calibration procedures will be used by the analytical laboratories, as specified in Appendix A

Calibration of equipment used to perform geotechnical testing will be in accordance with that specified in the ASTM Method D 422-63 for hydrometer and sieve analyses (Annual Book of ASTM Standards, Volume 04 08, 1984) The equipment calibrations, including those for ovens, thermometers and balances, shall be done at a minimum of every six months and prior to large scale testing

Field instruments will be calibrated according to procedures presented in Appendixes A and B of the IGMP/CSPCP Sampling Plan A calibration log book will be assigned to each field instrument, and all calibrations will be documented in the log books

7. ANALYTICAL PROCEDURES

Laboratory analyses will follow methods described in Tables 3 1, 3 2, 3 3, and 3 4 Deviation from those methods, if required, will be presented in the SSMPs

8. DATA REDUCTION, VALIDATION, AND REPORTING

Analytical laboratories will provide results to the Rockwell International CEARP Manager, the Subcontractor Project Manager, and Quality Assurance Officers These data will include results and documentation for blanks and duplicates, matrix spikes, and forms summarizing analytical precision and accuracy

Analytical data, including quality control sample analysis, will be entered into the technical data base The analyses will be grouped into lots, with quality control samples associated with a particular lot. The analyses of quality control samples will be compared to theoretical known concentrations of those samples If analyses do not meet acceptance criteria, the analytical laboratory may be asked to re-analyze the samples for parameters which do not exceed holding times Analyses which cannot meet acceptance criteria, will be labelled as unacceptable All parameter-specific values for a lot in which the quality control analyses did not meet acceptance criteria, will be removed from the technical data base

Acceptance criteria for analyses of parameters for quality control samples (knowns) will be based on the theoretical known value furnished by the laboratory that prepared the sample The theoretical known value is stated as a range of values The analysis of the sample must be within the stated range of the theoretical known plus or minus 10% of the range An exception is analyses at or near the limit of detection If the lower limit of the range of the theoretical known value is less than twice the limit of detection, an acceptable analysis includes the range from the limit of detection to the upper limit of the theoretical range, plus 10%

Analytical reports from a field laboratory, if used, and the geotechnical laboratory will include all raw data, documentation of reduction methods, and related quality assurance/quality control data These data will be assessed by verification of reduction results and confirmation of compliance with quality assurance/quality control requirements

Raw data from field measurements and sample collection activities used in project reports will be appropriately identified Where data have been reduced or summarized, the method of reduction will be documented

The Quality Assurance Officers will review results of Quality Control-acceptance evaluations and will document acceptance or non-acceptance of data The Quality Assurance Officers will maintain records of quality control-acceptance tests These records will be subject to independent audit, which may include Los Alamos National Laboratory

9 INTERNAL QUALITY CONTROL PROCEDURES

Internal quality control procedures for the laboratory are those specified in Appendix A These specifications include types of audits required (e g, sample spikes, surrogate spikes, reference samples, controls, and blanks), frequency of audits compounds to be used for sample spikes and surrogate spikes, and quality control acceptance criteria for audits

The quality control checks and acceptance for data from a field laboratory, if used, and the geotechnical laboratory are described above in Sections 3 2 and 3 3 Quality control procedures for field measurements (pH, conductivity, and temperature) are limited to checking the reproducibility of the measurement in the field by obtaining multiple readings and/or by calibrating the instruments (where appropriate) Quality control of field sampling will involve collecting field duplicates and blanks

10. PERFORMANCE AND SYSTEMS AUDITS

For each activity where samples are collected, a performance audit investigating conformance with quality control procedures will be conducted (Appendix A) at the discretion of the Rockwell International CEARP manager, Subcontractor Project Manager, and Quality Assurance Officers This audit will be scheduled to allow oversight of as many different field activities as possible This audit will be performed by the Quality Assurance Officers or their designees. A written report of the results of this audit, along with a notice of nonconformity (if necessary), will be submitted to the following individuals:

- Rockwell International CEARP Manager
- Subcontractor Project Manager
- Subcontractor Site Manager

At least one systems audit will be performed during the project The audit will verify that a system of quality control measures, procedures, reviews, and approvals was established for all activities and is being used by project personnel It will also verify that the system for project documentation is being used and that all quality control records, along with required quality control reviews, approvals, and activity records are being maintained. A standard checklist for systems audits will be used The systems audit will be conducted by the Quality Assurance Officers and/or Los Alamos National Laboratory A final report will be prepared which summarizes any deviations from approved methods and their impacts on the project results

After consultation with the CEARP Manager (and Subcontractor Project Manager), the Quality Assurance Officers may schedule systems audits of the participating laboratories At a minimum, the systems audit would include inspection of laboratory notebooks, control sheets, logsheets, computer files, and equipment calibration and maintenance records If scheduled, system audits will be executed by individuals identified in Section 2.3 of this document.

Performance and systems audits of analytical laboratories will be scheduled and executed by the laboratory Quality Assurance Officers. Performance audits are conducted at least semiannually

11. PREVENTIVE MAINTENANCE

This section applies solely to field equipment Preventive maintenance will be addressed by checks of equipment prior to initiation of field operations, to allow time for replacement of malfunctioning equipment The Subcontractor Site Manager will be responsible for implementing and documenting these procedures on a weekly basis during the period of use

12. LABORATORY DATA ASSESSMENT PROCEDURES

Analytical data from laboratories is assessed for accuracy, precision and completeness by the laboratory Quality Assurance Officers, using standard procedures

Assessment of data generated by analytical laboratories is initiated and continued at three administrative levels The bench chemist directly responsible for the test knows current operating acceptance limits He/she can directly accept or reject generated data and consult with his/her immediate supervisor for any corrective action Once the bench chemist has reported the data as acceptable, he/she initials the report sheet Any out-of-control results are flagged and a note is made as to why the results were reported

The chief chemist receives the data sheets and reviews the quality control data that accompanied the sample run After checking the reported data for completeness and quality control results, the chief chemist either initials the report sheet or sends it back to the bench chemist for rerunning of samples The Quality Control Coordinator reviews data forwarded to him/her as acceptable by the chief chemist Any remaining out-of-control results that, in the opinion of the Quality Control Coordinator, do not necessitate rerunning of the sample, are flagged, and a memo is written to the data user regarding utility of the data Data generated from all analyses are given a final review by the laboratory Quality Assurance Officers

13 CORRECTIVE ACTION PROCEDURES

The Quality Assurance Officers and their audit teams will prepare a report describing the results of the performance and/or system audits If unacceptable conditions (e g , failure to have/use procedures), unacceptable data, nonconformity with the quality control procedures, or a deficiency are identified, the Quality Assurance Officers will notify the Rockwell International CEARP Manager of the results of the audit in writing They will also state if the nonconformity is of significance for the program and recommend appropriate corrective actions The Rockwell International CEARP Manager will be responsible for ensuring that correcitve is developed and initiated and that, if necessary, special expertise not normally available to the project team is made available The subcontractor will be responsible for carrying out corrective actions The subcontractor will also ensure that additional work is not performed until the nonconformity is corrected Corrective action may include

- reanalyzing the samples if holding time permits,
- resampling and reanalyzing,
- evaluating and amending the sampling and analytical procedures, and
- accepting the data and acknowledging its level of uncertainty

The Rockwell International CEARP Manager will be responsible for ensuring that corrective action was taken, and that it adequately addressed the nonconformity

After corrective action is taken, the Quality Assurance Officer responsible for the audit will document its completion in a written report The report will indicate any identified findings, corrective action taken, follow-up action, and final recommendations The report will be sent to the Rockwell International CEARP Manager Project staff will be responsible for initiating reports on suspected nonconformities in field activities and deliverables or documents

14 QUALITY ASSURANCE REPORTS

The Rockwell International CEARP Manager will rely on written reports/memoranda documenting data assessment activities, performance and systems audits, nonconformity notices, corrective action reports, and quality assurance notices to enforce quality assurance requirements. The Los Alamos National Laboratory will be issued a written quality assurance report at the end of each stage of site characterization (remedial investigation) by the Rockwell International CEARP Manager

Records will be maintained to provide evidence of quality assurance activities Proper maintenance of quality assurance records is essential to provide support for evidential proceedings and to assure overall quality of the investigation A quality assurance records index will be started at the beginning of the project All information received from outside sources or developed during the project will be retained by the project team. Upon termination of an individual task or work assignment, working files will be processed for storage as quality assurance records Upon termination of the project, complete documentation records (for example, chromatograms, spectra, and calibration records) will be archived as required by DOE Order 1324 2A (Records Deposition) The Rockwell International CEARP Manager and the Los Alamos National Laboratory CEARP Rocky Flats Plant Team Leader will be responsible for ensuring that the Quality Assurance records are being properly stored and that they can be retrieved

15. REFERENCES

DOE 1986b "Comprehensive Environmental Assessment and Response Program Phase 1 Draft Installation Assessment Rocky Flats Plant," US Department of Energy unnumbered draft report, April 1986

APPENDIX A

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

APPENDIX 4

WEST SPRAY FIELD
HYDROGEOLOGIC CHARACTERIZATION REPORT

WEST SPRAY FIELD

HYDROGEOLOGIC CHARACTERIZATION REPORT

ROCKY FLATS PLANT

GOLDEN, COLORADO

OCTOBER 3, 1988

Prepared for

Rockwell International
Aerospace Operations
Rocky Flats Plant
Golden, Colorado 80401

Prepared by

Roy F Weston, Inc
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228

TABLE OF CONTENTS

TABLE OF CONTENTS
(CONTINUED)

TABLE OF CONTENTS
(CONTINUED)

APPENDICES

LIST OF PLATES

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES
(CONTINUED)

LIST OF TABLES
(CONTINUED)

SECTION 1

CONCLUSIONS AND RECOMMENDATIONS

Results of hydrogeologic investigations at the West Spray Field suggest that spray application of liquids from the Solar Evaporation Ponds 207B North and Center may have resulted in elevated levels of nitrate in the alluvial ground water Sulfate and sodium ions were also elevated above background The total dissolved solids (TDS) showed generally higher values than background in the potentially impacted areas Only nitrate occurs at concentrations above the proposed concentration limit

Alluvial ground-water flow in the West Spray Field Area reflects regional and local topography Ground water enters the West Spray Field Area from the west and generally flows east-northeastward following topography Alluvial ground-water flow is sensitive to the overall elevation of the water table during the course of a year When the elevation of the water table is relatively high and saturated thickness is great, ground water exhibits a more eastwardly component of flow than when the elevation of the water table and saturated thicknesses are reduced

The following activities will further define ground-water flow directions and rates as well as ground-water quality at the West Spray Field

1) Additional background wells will be installed south and sidegradient of the West Spray Field to better characterize background ground-water quality

2) Additional downgradient and sidegradient wells will be installed immediately adjacent to the spray field during Interim Status monitoring to define ground-water flow directions and quality

3) An additional alluvial well will be installed near the center of the spray field to evaluate alluvial ground-water flow directions within the area

4) All 1986 wells will be resurveyed

5) Quarterly ground-water monitoring will continue at the West Spray Field

6) Monthly water level measurements will also continue

SECTION 2

INTRODUCTION

This report presents a geologic and hydrogeologic characterization of the West Spray Field The West Spray Field at the Rocky Flats Plant was first identified as a RCRA regulated unit in the fall of 1985 when the initial facility Part B application was in preparation At that time, it was determined that certain waste streams being disposed at the West Spray Field were RCRA hazardous wastes Shortly thereafter, it was determined that continued disposal of hazardous wastes at the West Spray field would cease Hence, a closure plan for interim status closure of the West Spray Field is required pursuant to Part 265 of the Colorado State Hazardous Waste Regulations (6 CCR) and Title 40, Part 265 of the Code of Federal Regulations (40 CFR) The goal of the closure plan is to meet closure performance standards as follows

- o The owner or operator must close the facility in a manner that a) minimizes the need for further maintenance, and b) controls, minimizes or eliminates, to the extent necessary, to protect human health and the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated rainfall, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere (6 CCR and 40 CFR 264 111)

- o The owner or operator must provide a detailed description of the steps needed to remove or decontaminate all hazardous waste residues and contaminated containment system components, equipment, structures, and soils during partial and final closure including, but not limited to, procedures for cleaning equipment and removing contaminated soils, methods for sampling and testing surrounding soils, and criteria for determining the extent of decontamination required to satisfy the closure performance standard [6 CCR at 40 CFR 264 112(b)(4)]

- The owner or operator must provide a detailed description of other activities necessary during closure period to ensure that all partial closures and final closure satisfy the closure performance standards, including, but not limited to, ground-water monitoring, leachate collection, and run-on and run-off control [6 CCR and 40 CFR 264 112(b)(5)]

- During the partial and final closure periods, all contaminated equipment, structures and soil must be properly disposed of, or decontaminated unless specified otherwise in 264 280 (6 CCR and 40 CFR 264 114)

A closure plan was submitted on November 28, 1986, for the West Spray Field as part of the RCRA Post-Closure Care Permit Application for the Rocky Flats Plant (Rockwell International, 1986a) It was prepared in accordance with 6 CCR and 40 CFR 265 Interpretations and conclusions incorporated in this report supersede those in the 1986 Post-Closure Care Permit Application

2 1 REPORT OVERVIEW

This report provides results of the 1986 and 1987 site characterization investigation performed at the West Spray Field at Rocky Flats Plant Historical aerial photographs and previous investigations were also sources of information for this report (Colorado Aerial Photo Service 1968, 1970, 1972, 1974-1985, U S Geol Survey, 1971, Scharf & Associates, 1986, Agricultural Stabilization and Conservation Service, 1969, Woodward-Clevenger, 1974, Zeff et al , 1974, and Lord, 1977)

Presented in this introduction are site location and description, objectives of this study, and a summary of previous investigation results The introduction is followed by a regional setting chapter (Section 3) which describes climatology, physiography, geology, ground-water hydrology, and surface water hydrology in the vicinity of Rocky Flats Plant Section 4, Soils Characterization, provides a chemical characterization of the soils and Solar Evaporation Pond sludges and liquids Section 5 describes the site hydrogeology, including site geologic setting, ground-water flow paths, and water quality

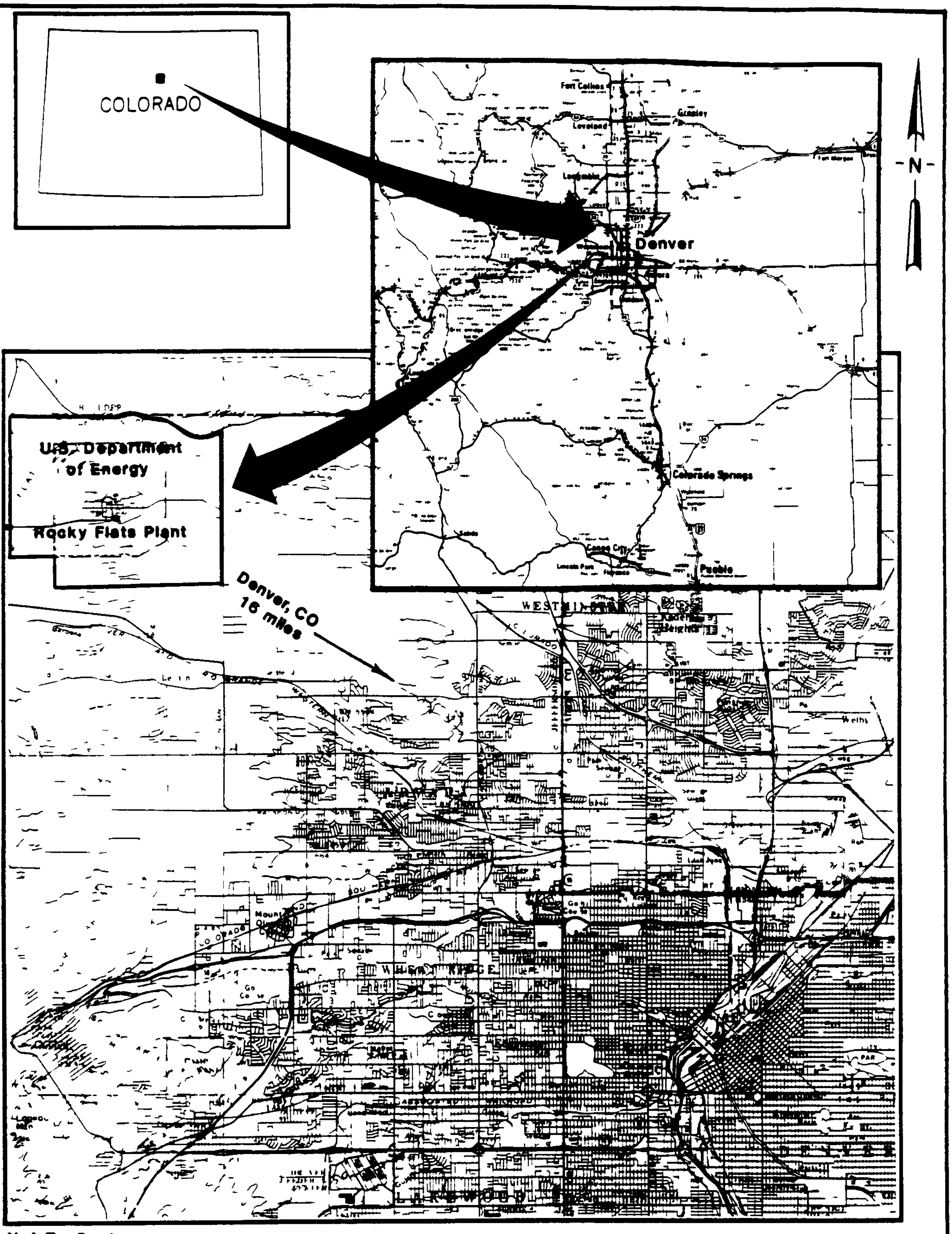
Appendices A through E contain supporting data The sampling plans for the 1986 and 1988 field work are presented in Appendix A Appendices B and C contain the hydrogeologic data and test pit data, respectively Appendix D contains the analytical data Appendix E contains 1986 soils analytical data

2 2 SITE LOCATION AND DESCRIPTION

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 2-1) The Plant consists of approximately 6,550 acres of federally owned land in Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th Principal Meridian Major buildings are located within the Plant security area of approximately 400 acres The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 2-2)

This site characterization report addresses the West Spray Field located within the Rocky Flats property boundary just west of the controlled area of the Rocky Flats Plant (Figure 2-2) This site was identified as a regulated unit because materials contaminated with listed hazardous wastes were disposed at the West Spray Field

The West Spray Field was in operation from April 1982 to October 1985 During operation, excess liquids from solar evaporation ponds 207B North and Center were pumped periodically via pipeline to the West Spray Field for spray application Based on interviews and examination of aerial photographs, the exterior boundary of



Not To Scale

Figure 2-1: Location of Rocky Flats Plant the spray field and three direct application areas have been located (Figure 2-3) (Rockwell 1986a)

The West Spray Field covers an area of approximately 4,577,000 square feet or approximately 105 1 acres Three areas, where direct application of the liquids occurred, have been designated Areas 1, 2, and 3 for the purpose of this report (Figure 2-3) Area 1 is approximately 1,533,000 square feet or about 35 6 acres in surface area Area 2 is approximately 1,360 feet by 80 feet in size, with a surface area of 109,000 square feet or about 2 5 acres Area 3 is an oval area made up of small circular application areas all with a radius of approximately 100 feet The total surface area of Area 3 is approximately 3 2 acres The total combined area of direct application is about 41 3 acres or about one-third of the total West Spray Field area

Spray application was initially done by two self-propelled spray irrigation lines mounted on metal wheels with impulse heads These portable lines were replaced by three fixed irrigation lines with impulse heads A spray impulse cannon was also utilized in Area 3 The photographs indicate some surface run-off occurred into the unnumbered areas within the approximate location of the spray field's exterior boundary Limited quantities of windblown spray probably also contributed to the vegetation patterns observed on the aerial photographs (Rockwell 1986a)

2 3 OBJECTIVES

The objectives of this study are to characterize site geology, hydrology, and the extent of contamination at the West Spray Field This information will be used to support closure activities and develop post-closure care and monitoring programs Post-closure care activities and monitoring programs are presented in the Post-Closure

Care Permit Application In addition, an evaluation of the ground-water quality and hydrogeology are presented along with recommendations for additional field work

2 4 SUMMARY OF PREVIOUS INVESTIGATIONS

A series of investigations have been conducted at the Plant to characterize ground water, surface water, and soils A summary of investigations performed at the West Spray Field is presented below

In 1975, the U S Department of Agriculture Soil Conservation Service conducted investigations in Jefferson County as part of a soil survey The investigation provided soil survey maps, soil map unit descriptions including physiography, soil characteristics, use and management, soil series interpretations for various soils and general description of the soils for the area The Rocky Flats Plant site was included in this soil survey

Hydro-Search, Inc (1985) presented a hydrogeologic characterization of the Rocky Flats Plant This report describes the hydrogeologic and ground-water quality conditions at the Plant based on data existing at the time The ground-water monitoring system was described and evaluated, and recommendations were made for a new monitoring program

In 1986, R L Henry (Rockwell International) submitted a report summarizing trends observed in the surface water monitoring at Rocky Flats Plant The report discusses the surface water control system (SWCS) completed in 1980, which is designed to divert flow around Plant site and collect surface runoff and store it temporarily for monitoring before discharge Henry also discusses non-radioactive and radioactive trends in the surface water quality

Chen and Associates (Rockwell International, 1986a) prepared a closure plan for the West Spray Field at Rocky Flats Plant This plan describes the operation procedures at the West Spray field including spray application policies and procedures, waste inventory, waste characteristics, application rates, waste transfer equipment, and storage and pretreatment facilities

Chen and Associates (Rockwell International, 1986b) also prepared a preliminarv prioritization of sites at Rocky Flats Plant The prioritization of sites was based on review of previous investigations and historical aerial photographs

Nine ground-water monitoring wells, two upgradient, four downgradient of the West Spray Field, and three adjacent to the West Spray Field, were installed in 1986 according to the procedures outlined in Rockwell International (1986c) These wells were installed to characterize the hydrogeology in the vicinity of the West Spray Field and to evaluate whether the West Spray Field was an imminent threat to the public or the environment The work plan for the 1986 field program is presented in Rockwell International (1986d), and Plate 2-1 presents monitor well locations at Rocky Flats Plant

Tracer Research (1986) conducted a shallow soil-gas investigation at the Rocky Flats Plant Ninety-five soil-gas and shallow ground-water samples were collected and analyzed The objective of the investigation was to locate extent of halocarbon contamination

WESTON conducted a soil sampling investigation in the West Spray Field in 1986 The investigation evaluated potential volatiles, semi-volatiles, pesticides, metals, radionuclides, and RCRA waste characteristics present due to application of liquids from Solar Evaporation Ponds 207B North and Center (WESTON, 1986b and 1986c)

The investigation concluded that the soils at the West Spray Field would not be classified as a hazardous waste under RCRA All parameters of concern occurred in low concentrations and/or below laboratory detection limits

Additional soil sampling was conducted in 1988 in the West Spray Field area The investigation was conducted by excavating test pits across three defined soil horizons and collecting samples in each soil horizon The investigation evaluated potential volatiles, semi-volatiles, uranium, plutonium, gross alpha, gross beta, nitrates, lead, and mercury Results of the investigation are discussed in Section 4, Soils Characterization

Rockwell International (1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986e, and 1987a) are annual environmental monitoring reports These reports summarize annual monitoring, data collection, analyses, and evaluations of programs at the facility Annual environmental monitoring programs include ambient air, surface water, ground water, soils, and regional water supplies in the vicinity of the Rocky Flats Plant

SECTION 3

REGIONAL SETTING

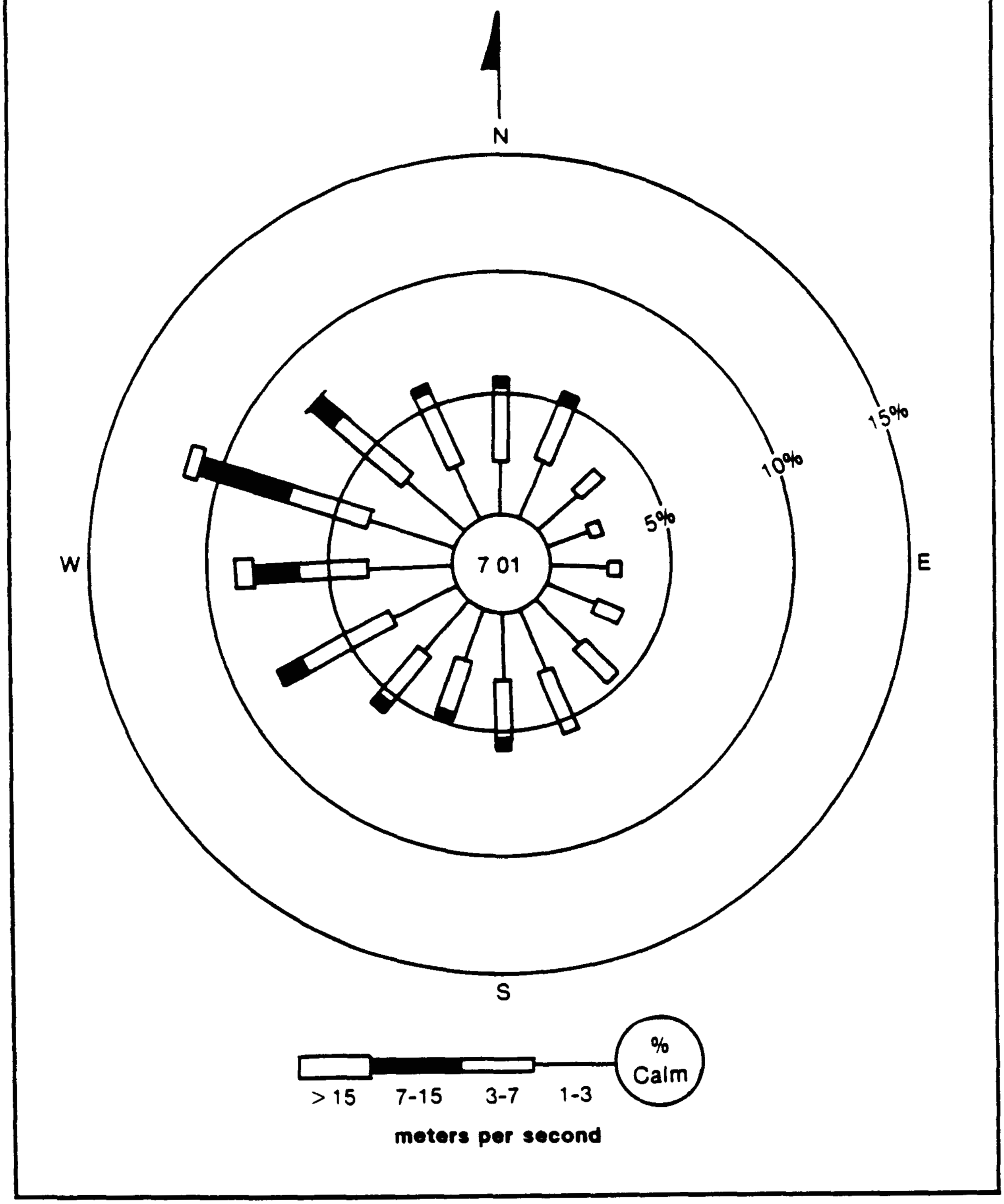
This section presents the regional setting of Rocky Flats Plant, including discussions of climatology, physiography, geology, ground-water hydrology, and surface water hydrology Site-specific discussions of hydrogeology and surface water hydrology at the West Spray Field are presented in Sections 4 0 and 5 0, respectively

3 1 CLIMATOLOGY

The area surrounding the Rocky Flats Plant has a semiarid climate typical of the Rocky Mountain region However, the elevation of the Plant and the nearby slopes of the Front Range slightly modify the regional climate

Winds at Rocky Flats Plant, although variable, are predominantly from the west-northwest Stronger winds occur during the winter, and the area occasionally experiences Chinook winds with gusts up to 100 miles per hour because of its location near the Front Range (DOE, 1980) Figure 3-1 shows the wind direction, frequency, and average velocity for each direction as recorded in 1985

Temperatures are moderate, extremely warm or cold weather is usually of short duration On the average, daily summer temperatures range from 55 to 85 degrees Fahrenheit (F) and winter temperatures range from 20 to 45 degrees F Temperature extremes recorded at the Plant have ranged from 102 degrees F on July 12, 1971 to -26 degrees F on January 12, 1963 The 24-year daily average maximum temperature for the period 1952 to 1976 was 76 degrees F, the daily average minimum



(after Rockwell International, 1987a)

Figure 3-1:
1986 Annual Wind Rose for the Rocky Flats Plant

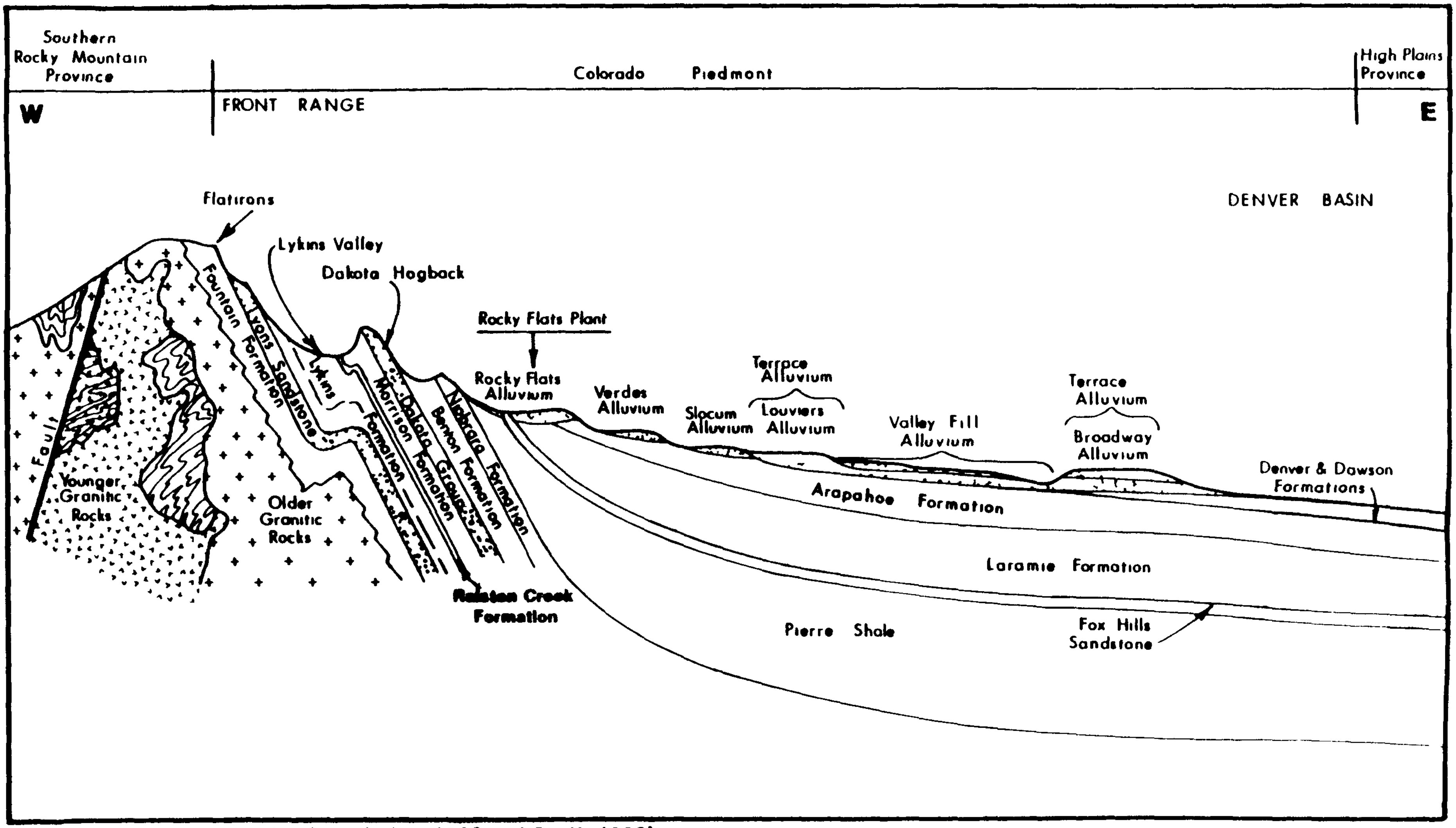
was 22 degrees F, and the average annual mean was 50 degrees F Average relative humidity was 46 percent (DOE, 1980)

Average annual precipitation at the Plant is 15 inches Approximately 40 percent of the precipitation falls during the spring season, much of it as snow Thunderstorms from June to August account for an additional 30 percent of the precipitation Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively Snowfall averages 85 inches per year, generally occurring between October and May (DOE, 1980)

3 2 PHYSIOGRAPHY

The Rocky Flats Plant is located at an elevation of approximately 6,000 feet above mean sea level The site is on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Fenneman, 1931) The Colorado Piedmont ranges in elevation from 4,000 feet on the east to 7,000 feet on the west The Piedmont merges to the east with the High Plains section of the Great Plains Province and is terminated abruptly on the west by the Front Range section of the Southern Rocky Mountain Province (Figure 3-2)

The Colorado Piedmont is an area of dissected topography and denudation where Tertiary strata underlying the High Plains have been almost completely removed In a regional context, the piedmont represents an old erosional surface along the eastern margin of the Rocky Mountains It is underlain by gently dipping sedimentary rocks (Paleozoic to Cenozoic in age), which are abruptly upturned at the Front Range to form hogback ridges parallel to the mountain front The piedmont surface is broadly rolling and slopes gently to the east with a topographic relief of



(after Boulder County Planning Commission, 1983 and Scott, 1960)

Not To Scale

Figure 3-2:
Generalized East-West Cross Section
Front Range to Denver Basin

only several hundred feet This relief is due both to resistant bedrock units that locally rise above the surrounding landscape and to the presence of incised stream valleys Major stream valleys which transect the piedmont from west to east have their origin in the Front Range Small local valleys have developed as tributaries to these major streams within the piedmont In the area of the Plant, a series of Quaternary pediments have been eroded across this gently rolling surface (DOE, 1980)

The eastern margin of the Front Range a few miles west of the Plant is characterized by a narrow zone of hogback ridges and flatirons formed by steeply east-dipping Mesozoic strata (such as the Dakota Sandstone and the Fountain Formation) Less resistant sedimentary units were removed by erosion (Figure 3-2) The Front Range reaches elevations of 12,000 to 14,000 feet above mean sea level 15 miles farther west The range itself is broad and underlain by resistant gneiss, schist and granitic rocks of Precambrian age The resistant nature of these rocks has restricted stream erosion so that deep, narrow canyons have developed in the Front Range

Several pediments have been eroded across both hard and soft bedrock in the area of the Plant during Quaternary time (Scott, 1963) The Rocky Flats pediment is the most extensive of these, forming a broad flat surface south of Coal Creek The broad pediments and more narrow terraces are covered by thin alluvial deposits of ancient streams draining eastward into the Great Plains The sequence of pediments reflects repetitive physical processes associated with cyclic changes in climate Each erosional surface and stratigraphic sequence deposited on it probably represents a single glacial cycle The oldest and highest pediment, the Subsummit Surface (Scott, 1960), truncates the hogback ridges of the Front Range Three successively younger pediments, veneered by alluvial gravels, extend eastward from the mountain front Erosion of valleys into the pediments followed each depositional cycle so that, near the mountain front, stratigraphically younger geologic units occur at topographically lower elevations as narrow terrace deposits along the streams From oldest to youngest, the three pre-Wisconsin deposits are the Rocky Flats Alluvium, the Verdos Alluvium and the Slocum Alluvium (Scott, 1965) A series of Wisconsin and post-Wisconsin terrace deposits are present at lower elevations along streams that have incised the older pediments (east of the Plant) These alluvial deposits are described in Section 3 3 3, Surficial Geology

The Rocky Flats Plant is located on a relatively flat surface of Rocky Flats Alluvium The pediment surface and overlying alluvium (generally 10 to 50 feet thick, although the alluvium is as much as 100 feet thick west of the Plant) have been eroded by Walnut Creek on the north and Woman Creek on the south so that terraces along these streams range in height from 50 to 150 feet The grade of the gently eastward-sloping, dissected Rocky Flats Alluvium surface varies from 0 7 percent at the Plant to approximately 2 percent just east of the Plant

3 3 REGIONAL GEOLOGY

3 3 1 Geologic and Stratigraphic History

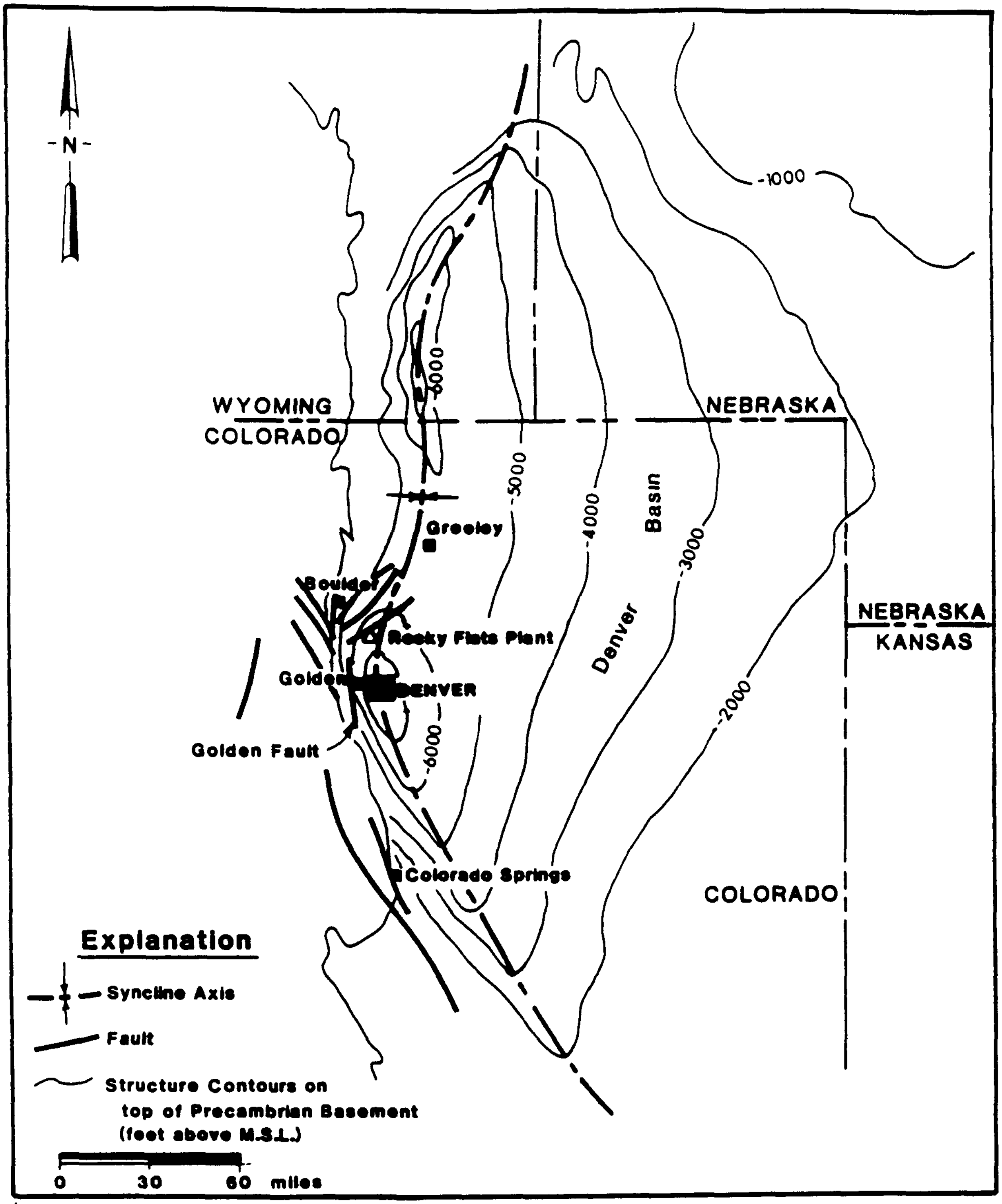
This section describes the regional geologic and stratigraphic history in the vicinity of the Plant, including the Denver Basin Section 4 0 describes the site specific geology and stratigraphy of the West Spray Field Area

The Rocky Flats Plant is located on the northwestern flank of the Denver Basin and is underlain by about 12,000 feet of Paleozoic and Mesozoic sedimentary rocks (Hurr, 1976) The Denver Basin is an asymmetric syncline that formed during the Late Cretaceous Laramide Orogenv The western limb of the basin dips steeply to the east, and the eastern limb dips gently to the west (Figure 3-3)

The geologic history of northeastern Colorado involves several episodes of mountain building and oceanic transgression and regression, resulting in the deposition of thousands of feet of sedimentary rock on top of the Precambrian basement This section describes the geologic history beginning with Precambrian time Geologic descriptions of the various units are provided within this context More detailed descriptions of the units present on site are provided in Section 5 0

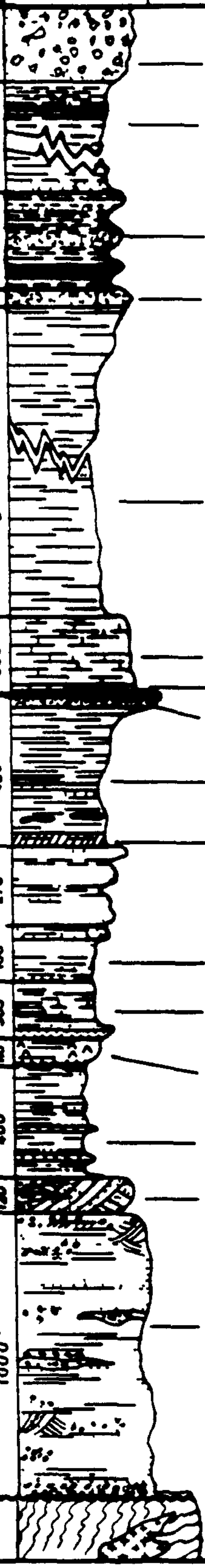
Early Precambrian tectonic, metamorphic, and plutonic igneous activity created a complex fabric in the basement rock of Colorado (Grose, 1972) The Precambrian units were covered by marine and continental sedimentation during the lower Paleozoic (carbonate and siliciclastic rock units were deposited unconformably on the Precambrian basement) Most of these units were later eroded by multiple Paleozoic diastrophisms, thus removing Cambrian to Mississippian rocks from the Denver Basin area (Kent, 1972)

Middle Pennsylvanian orogenic activity formed the Ancestral Rockies, and the Fountain Formation was deposited unconformably on the uplifted Precambrian basement (Figure 3-4) The Fountain Formation contains coarse clastics derived from the erosion of the Ancestral Rockies and deposited as alluvial fans along a continental margin (Martin, 1965) The result was nonmarine sedimentation that occurred in northeastern Colorado from the Triassic to early Cretaceous This sedimentation deposited a sequence of aeolian, fluvial-deltaic, and lacustrine units



(after Rockwell International, 1986a)

Figure 3-3: STRUCTURE OF THE DENVER BASIN



AGE	FORMATION	[illegible]	SUMMARY DESCRIPTION
TERTIARY	Green Mountain	600'	Boulder conglomerate with occasional thin siltstone lenses
	Denver - Arapahoe	1200'	Tan sandy clavstone and clavev sandstone, conglomerate at base, includes Table Mountain "flow" rocks to the north
UPPER CRETACEOUS	Laramie	500'	Grav, fine-to-medium-grained sandstone and silty clavs, thin coal beds in lower part
	Fox Hills	[illegible]	Tan, fine-to-medium-grained sandstone and sandv shale
	Pierre	± 8000'	Dark grav, silty shale and few thin, silty sandstones
	Niobrara	350'	Dark gray, very calcareous shale "Foraminifers" abundant (Smoky Hills Member) Light gray, dense, fossiliferous limestone(Fort Hays Member)
	Benton	420'	Brown, sandy, fossiliferous limestone Dark gray shale with bentonite streaks, thin limestones in middle part, few cone-in-cone concretions in lower part Dark gray, brittle silty shale (Mowry)
LOWER CRETACEOUS	Dakota Group: So Platte	270'	Light gray, fine-to-medium-grained sandstone, several dark gray shales in middle part
	Dakota Group: Lytle	100'	Light grav, tine-to-coarse-grained, locally conglomeratic sandstone, frequent red and green siltstone interbeds
Jurassic	Morrison	365'	Gray to greenish-gray to red shale and siltstone, thin limestones in middle part, lenticular sandstones in upper and lower part
	Ralston Creek	[illegible]	Light tan siltstone and light red, silty shale, gypsiferous, sandstone at base and locally conglomeratic
Tri-assic?	Lykins	400'	Red siltstone with two laminated limestones in lower part
PERMIAN	Lyons	120'	Grayish-white, fine-to-medium-grained cross-bedded sandstone, conglomeratic lenses frequent
PENNSYLVANIAN	Fountain	1000'	Red, fine-to-coarse-grained sandstone and conglomerate, arkosic, thin, lenticular red siltstones frequent throughout
PRECAMBIAN			Gneiss, schist, and small granitic intrusions

(after LeRoy and Weimer, 1971)

Figure 3-4: GENERALIZED STRATIGRAPHIC SECTION, Golden-Morrison Area

known as the Lyons, Lykins, Ralston Creek, Morrison, and Dakota Formations (Figure 3-4) (Kent, 1972)

The Pierre Shale, consisting of more than 5,600 feet of shales and siltstones, was deposited in the final phases of oceanic sedimentation The sedimentation resulted from the last oceanic transgression occurring 100 million years ago during the late Cretaceous This transgression formed an epicontinental sea called the Cretaceous Seaway that covered the eastern portions of New Mexico, Colorado, and Wyoming

Following deposition of the Pierre, the ocean began to regress and deposition of the Upper Cretaceous Fox Hills and Laramie Formations occurred These formations contain sandstones, siltstones, claystones, and coals deposited in fluvial-deltaic and lacustrine environments (Weimer, 1973) Deposition of the Laramie was influenced and then stopped by the Laramide Orogeny, a major mountain building event that began in the late Cretaceous and caused uplift of the Colorado Front Range Mountains and the eastward tilting of the Denver Basin

The Upper Cretaceous Arapahoe Formation was deposited on an erosional surface marking the end of deposition of the Laramie Major uplift of the Front Range and downwarp of the Denver Basin continued during deposition of the Arapahoe Formation Coarse pebble conglomerate lenses deposited in alluvial fans commonly occur in the Lower Arapahoe, however, conglomerate lenses have not been found at Rocky Flats Plant Claystone and sandstone units flank and top the alluvial fan deposits (Weimer, 1973)

The Denver Formation was deposited above the Arapahoe and is over 600 feet thick This formation contains a variety of lithologies including siltstones, arkoses, conglomerates, and basalt flows (near Golden, Colorado) (Robson, 1984)

The Dawson Formation was deposited above the Denver in a similar geologic environment during the late Cretaceous and early Tertiary Robinson (1972) described the Dawson Formation as a stratigraphic equivalent to the Denver Formation in southern portions of the Denver Basin However, Robson (1984) mapped the Dawson as a separate, younger (Tertiary) formation occurring above the Denver The Dawson is up to 600 feet thick and consists of conglomerates, sandstones, and shales (Robson, 1984)

The Tertiary Green Mountain Conglomerate was deposited unconformably on the Denver Formation, and consists of conglomerates, sandstones, siltstones, and claystones deposited by a local fluvial system that occurred only in the Golden, Colorado, area This unit is only found capping Green Mountain, approximately 15 miles south of Rocky Flats Plant (Costa and Bilodeau, 1982)

The Rocky Flats Alluvium was deposited on top of a major erosional surface that developed in late Tertiary time Before deposition of the Rocky Flats Alluvium, both the Dawson and Denver Formations were completely removed by erosion The Green Mountain Conglomerate may never have been deposited at the site, but if it was, it also was removed by erosion The Rocky Flats Alluvium contains boulders, cobbles, gravels, sands, silts, and clays deposited in alluvial fans at the base of the Colorado Front Range Mountains (Hurr, 1976)

Following deposition of the Rocky Flats Alluvium, the material was partially removed by erosion and the resulting drainages repeatedly infilled with more recent sediments The Verdos Alluvium and the younger Slocum Alluvium are the result of drainage infilling associated with glacial activity Similar processes are occurring now with an active valley fill alluvium in the stream channels and a recent but stable terrace above the valley fill

3 3 2 Plant Bedrock Geology

Bedrock units mapped at the Plant consist of the Laramie and Arapahoe Formations (Rockwell International, 1986a) These are shown in cross section in Figure 3-5 Because of the thickness (750 to 800 feet) and low permeability of the Upper Laramie, it is considered to be the base of the hydrologic system which could be affected by Plant operations (Hurr, 1976) The Upper Laramie and overlying Arapahoe Formations are described below

Laramie Formation

The Laramie Formation is a fluvial sequence of sandstones, siltstones, claystones, and coals, which is subdivided into two major lithologic units a lower sandstone unit and an upper claystone unit The lower sandstone unit is exposed in clay pits west of the Plant, and the upper claystone unit was observed in outcrop and in cores of several 1986 monitor wells west of the Plant The descriptions presented below are taken from Rockwell International (1986a)

Lower Sandstone Unit The lower sandstone unit consists of light to medium gray, very fine- to medium-grained, well sorted, subrounded to subangular quartzose sand with up to 25% lithic fragments Sandstones are typically fair to poorly

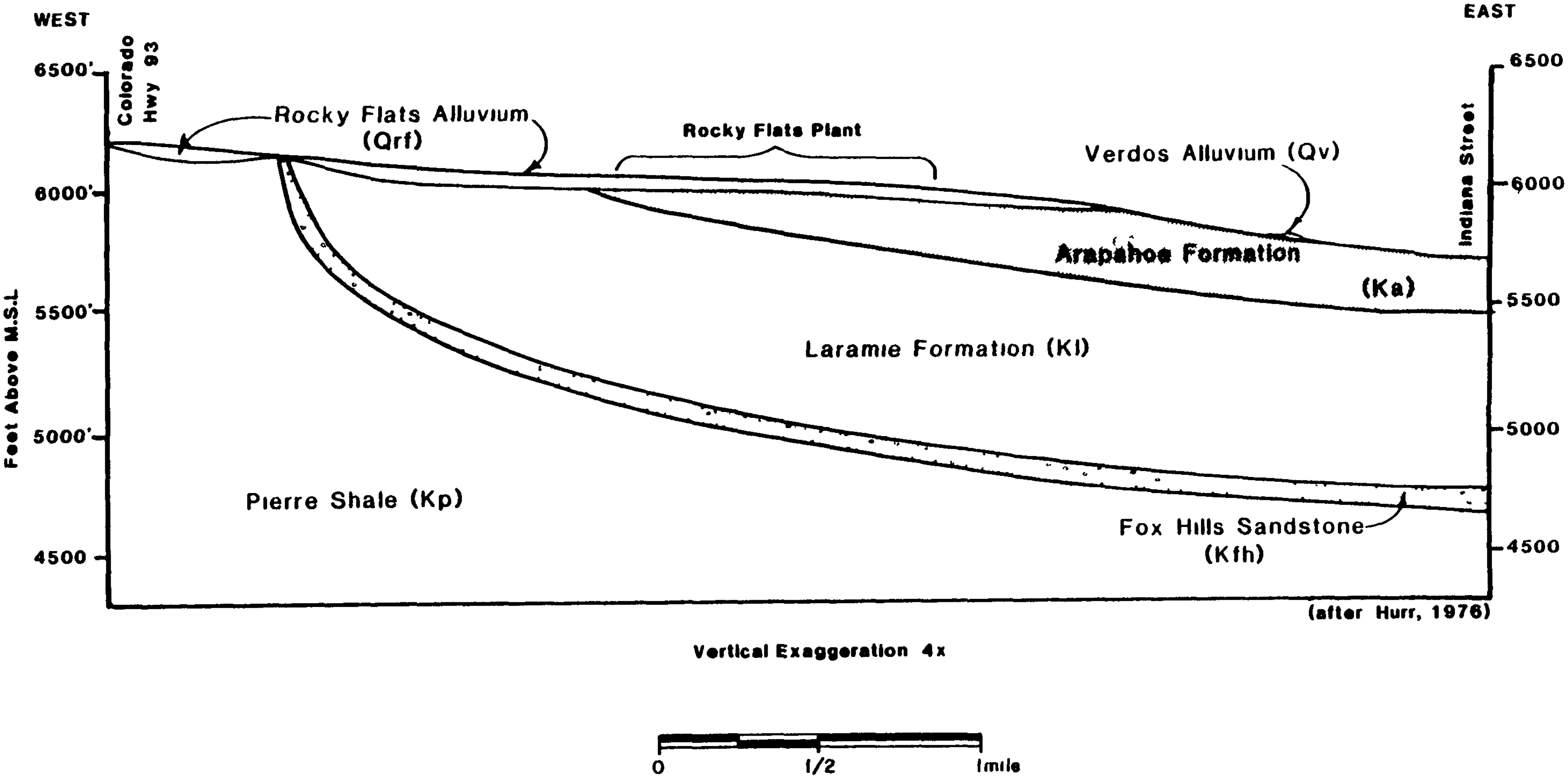


Figure 3-5: GENERALIZED CROSS SECTION OF ROCKY FLATS PLANT

indurated and cemented with silica Individual sandstone beds are 5 to 15 feet thick and are interbedded with white to light gray claystones The claystones are organic-rich and kaolinitic and have been mined from the clay pits west of the Plant Individual claystone beds are 10 to 15 feet thick Sedimentary structures observed in outcrop include planar, angular, and trough crossbeds, load structures, fluid escape structures, and ripple marks Plant fossil casts and molds of branches, stems, and leaves are concentrated along bedding planes The contact between the lower sandstone unit and the upper claystone unit is gradational and was selected where thick sandstone beds and kaolinite-rich claystones are less abundant

Upper Claystone Unit The upper claystone unit consists primarily of dark olive gray (5 Y 2/1) (GSA Rock Color Chart), poorly indurated claystones Upper Laramie claystones generally weather to a light olive gray (5 Y 4/1) and may have dark yellowish orange (10 YR 6/6) iron staining along bedding planes and secondary fractures These claystones appear quite similar to Arapahoe claystones in outcrop

Thin sandstone lenses (less than three feet thick) also occur in the upper Laramie These sandstones are typically yellowish gray (5 Y 8/1), fine- to very fine-grained, well sorted, subangular, and calcareous Core data (well 50-86) indicate that thin beds of white, kaolinite-rich claystone typical of the Lower Laramie occur in the Upper Laramie as well

The contact between the Upper Laramie claystones and the Lower Arapahoe sandstones is gradational and was selected using core data The contact was picked below the first Arapahoe sandstone greater than five feet thick (Rockwell

International, 1986a) This is consistent with the stratigraphic horizon picked as the base of the Arapahoe Formation at Rocky Flats Plant by Hurr (1976, 1985)

Arapahoe Formation

The Arapahoe Formation consists of fluvial claystones with interbedded lenticular sandstones and siltstones Contacts between these lithologies are both sharp and gradational The claystones are olive gray (5 Y3/2) to dark gray (N 3/0), poorly indurated, silty, and contain up to 15 percent organic material Weathering has penetrated from 10 to 40 feet into bedrock The weathered claystone is light olive gray, blocky, slightly fractured, and has iron staining as mottles and along bedding planes and fractures (Rockwell International, 1986a)

Sandstones in the Arapahoe Formation are light gray (N 6/0) to yellowish gray (5 YR 8/1), very fine- to medium-grained, with approximately 15 percent silt and clay The sandstones are lenticular, discontinuous, and stratigraphically complex The sand grains are subangular to subrounded and are predominantly quartzose with 10 percent lithic fragments The sandstones are poorly to moderately cemented and exhibit ripple marks, load casts, and planar, angular, and trough crossbedding Arapahoe Formation siltstones exhibit the same coloration, constituents, bedding characteristics, and sedimentary structures as the sandstones, however, they consist predominantly of silt-sized particles (Rockwell International, 1986a)

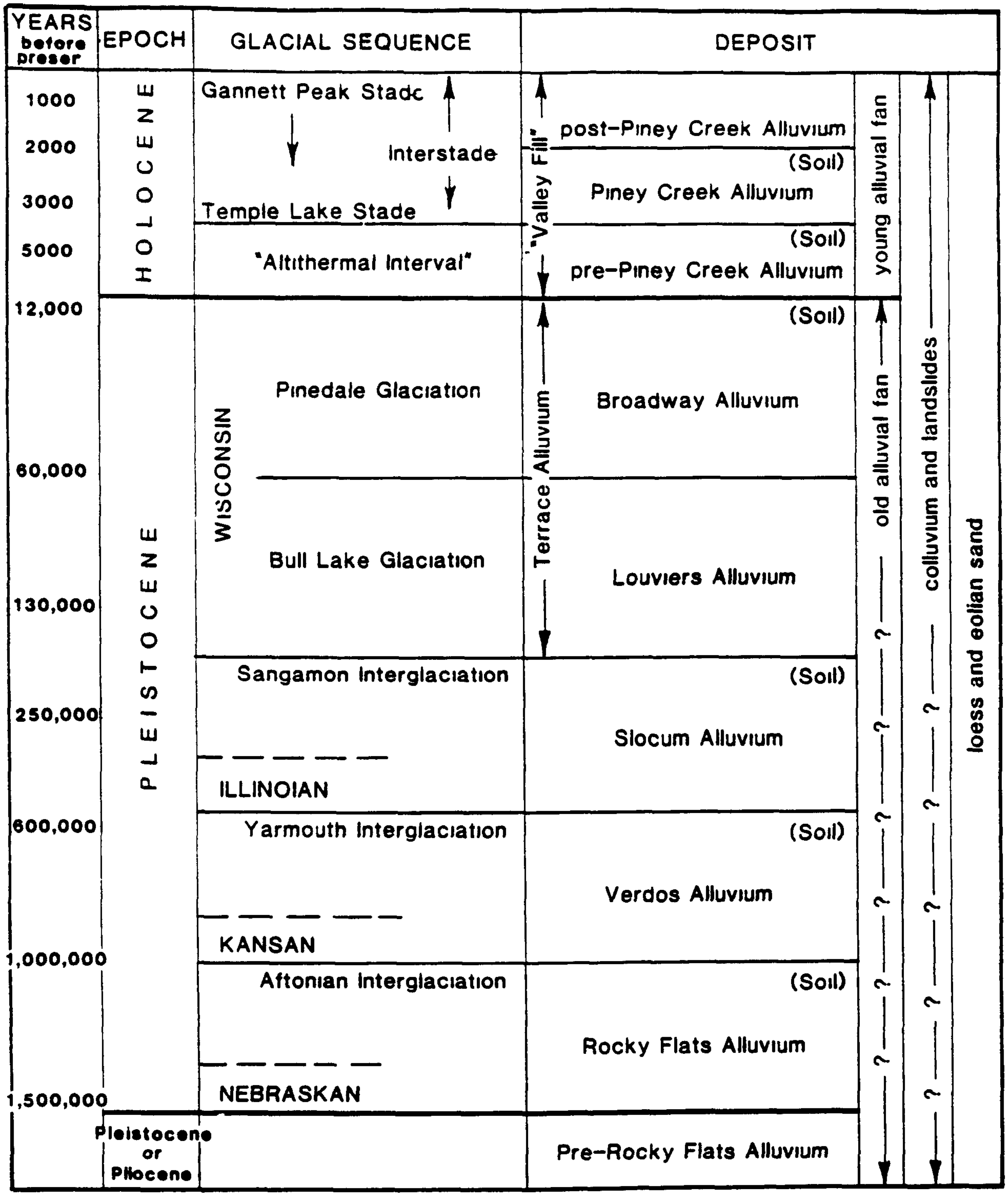
3 3 3 Plant Surficial Geology

There are six distinct Quaternary unconsolidated units of surficial materials in the vicinity of the Plant Rocky Flats Alluvium, Verdos Alluvium, Slocum Alluvium, terrace alluviums, valley fill alluvium, and colluvium (Figure 3-6)

The Rocky Flats Alluvium is topographically the highest and the oldest of the alluvial deposits The alluvium unconformably overlies the Laramie and Arapahoe Formations in the vicinity of the Plant The deposit is a series of laterally coalescing alluvial fans deposited by streams (Hurr, 1976) The fans were deposited on an erosional surface cut into the bedrock units, including channelization around the hogbacks of the lower Laramie

The alluvium consists of sand, clay, silt, gravel, cobble, and occasional boulder deposits Locally, the alluvium is cemented with calcium carbonate in the form of caliche Color of the alluvium is pale to dark yellowish brown The sands range from very fine-grained to medium-grained and poorly to moderately sorted The thickness of the alluvium is variable due to deposition on an erosional surface and recent erosional processes The alluvium is thickest to the west of the Plant, where less has been eroded, and thinnest to the east of the Plant (Rockwell International, 1986a)

Various alluvial deposits occur topographically below the Rocky Flats Alluvium in the drainages and include the Verdos, Slocum, terrace, and valley fill alluviums and colluvium (Figure 3-7) These deposits are primarily composed of reworked Rocky Flats Alluvium with the addition of some bedrock material Each unit is described below



(after Van Horn, 1976, and Scott, 1965)

Figure 3-6: SURFICIAL ALLUVIAL DEPOSITS IN THE ROCKY FLATS AREA

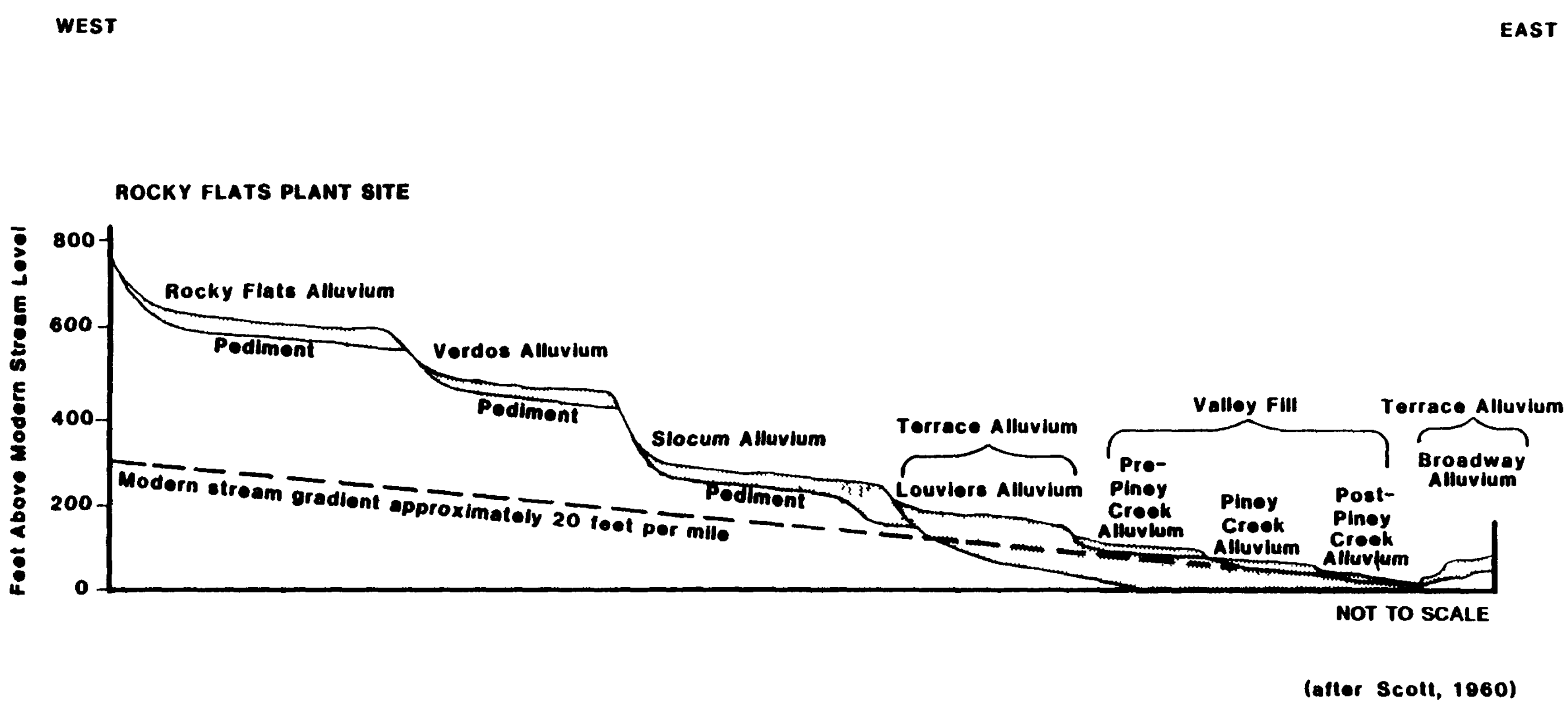


Figure 3-7:
EROSIONAL SURFACES AND ALLUVIAL DEPOSITS EAST OF THE FRONT RANGE, COLORADO

The Verdos Alluvium occupies a topographic position about 0 to 100 feet below the adjacent top of the Rocky Flats Alluvium The Verdos was deposited around the periphery of the present extent of the Rocky Flats Alluvium as fans and channel filling derived by erosion of the older Rocky Flats Alluvium The maximum thickness is about 40 feet, occurring as terraces in valleys east of the Plant The alluvium consists of unsorted gravels, sands, and clays similar to the Rocky Flats Alluvium, but the material is whitish gray in color (Rockwell International, 1986a)

The Slocum Alluvium is a poorly sorted gravel deposit containing much sand, silt, and clay derived from erosion of bedrock and the older gravel deposits The formation has a maximum thickness in the vicinity of the Plant of about 20 feet, but is commonly 5 to 10 feet thick It occupies a topographic position of about 150 to 300 feet below the top of the Rocky Flats Alluvium, and occurs downslope of the Verdos Alluvium in valleys east of the Plant site (Rockwell International, 1986a)

Locally, two Wisconsin-age terraces are associated with the present drainages The terrace alluvium occurs 5 to 35 feet above recent valley floors The alluvium is comprised of gravels, sands, and clays, derived from bedrock and reworking of older alluvial deposits The terrace alluvium can rarely occur up to 30 feet in thickness, however, the thickness is usually around 5 feet The alluvium occurs in valleys surrounding the Plant (Rockwell International, 1986a)

Valley fill alluvium occurs in the bottom of the present stream valleys around the Plant The valley fill ranges from dark-brown, sandy, clayey silt to moderately sorted cobbles and small boulders, recently reworked from previously deposited alluviums The valley fill along streams which head on the Rocky Flats Alluvium and have not yet cut through to bedrock tends to be coarse and have little or no fine material However, where the valley fill is deposited on bedrock, 0 5 to 2 feet of cobbly sand and gravel commonly is overlain by several feet of sandy, clayey silt (Rockwell International, 1986a) Subsequent erosion and deposition locally may have added more sand, gravel and cobbles on top of the silt, or cut through the valley fill to expose bedrock along the channel bottom (Hurr, 1976)

Colluvium, produced by mass wasting and downslope creep, collects on the sides and at the base of hills and slopes These deposits are poorly sorted mixtures of soil and debris from bedrock clay and sand mixed with gravel and cobbles derived from the older Rocky Flats Alluvium The colluvium consists predominantly of clay with common occurrences of sandy clay and gravel Color is yellowish brown to dusky brown and caliche is common locally The thickness of the colluvium ranges from 3 to 22 feet (Rockwell International, 1986a)

3 3 4 Regional Bedrock Structure

The general geologic structure of the area is north-striking sedimentary beds with dips to the east away from the Front Range Monocline Dips are quite steep west of the Plant in the Fox Hills Sandstone and Laramie Formation (on the order of 50 degrees or greater) These units are flanked on the west by Precambrian terrain of the Front Range Uplift and on the east by gently dipping sedimentary beds of the Denver Basin However, because the axis of the monocline onto the Front Range appears to be inclined to the east, dips become rapidly more gentle, on the order of 7 to 15 degrees beneath the Plant itself (Rockwell International, 1986a) A major bounding fault between the Front Range and the Denver Basin, the Golden Fault, runs north-south several miles west of the Plant at the mountain front (Figure 3-3)

The majority of the displacement on the Golden Fault, the uplift of the Front Range and subsidence of the Denver Basin, occurred during the late Cretaceous to early Eocene Laramide Orogeny about 40 to 70 million years ago (Martin, 1965) Erosion during the Laramide Orogeny is believed to have kept pace with uplift and the Front Range probably never stood very high above the Denver Basin during the orogeny By the late Eocene, an erosional surface of low relief covered much of the Rocky Mountain Region

The mountains west of the Rocky Flats Plant are the result of Post-Laramide tectonics and erosion About 5,000 to 10,000 feet of uplift has taken place in the Rocky Mountain Region since the early Miocene about 25 million years ago Late Tertiary block faulting is believed to have accompanied the regional uplift as indicated by apparent displacements of the late Eocene erosional surface (Scott, 1975 and Epis and Chapin, 1975) There is some evidence that block faulting has continued into the Quaternary (Scott, 1970, Whitkind, 1976, and Kirkham and Rogers, 1981)

In 1981, extensive studies were done to evaluate the Quaternary history of the Golden Fault and other faults at the Rocky Flats Plant and vicinity (Dames and Moore, 1981) The Golden Fault studies did not produce any evidence of tectonic activity along the Golden Fault within the past 500,000 years, and the fault does not have surficial expressions characteristic of geologically young fault zones

Hurr (1976) showed a fault crossing the eastern edge of the Plant, based on a series of bedding irregularities that appeared to be an extension of the previously mapped Eggleston Fault (northwest of the site) Further investigations of the feature (Dames and Moore, 1981) revealed that it is probably a penecontemporaneous growth fault attributed to slumping of the unconsolidated Arapahoe Formation before burial and lithification The Denver Basin has been tectonically stable for about 28 million years with the exception of a series of earthquakes associated with waste injection at the Rocky Mountain Arsenal in the 1960s and possible surface rupture on the Golden Fault approximately 600,000 years ago (Kirkham and Rogers, 1981)

3 4 REGIONAL GROUND-WATER HYDROLOGY

There are two hydraulically connected ground-water systems at the Rocky Flats Plant These systems occur in the surficial material (Rocky Flats Alluvium, colluvium, and valley fill material) and the underlying bedrock formations (Laramie-Fox Hills Formations and the Arapahoe Formation) These are discussed individually below

3 4 1 Unconfined Surficial Flow Systems

Recharge/Discharge Conditions

The shallow ground-water flow system occurs in the Rocky Flats Alluvium and other surficial materials under unconfined conditions The alluvium is recharged by infiltration of incident precipitation, irrigation, and surface water diversion canals (primarily through the Rocky Flats Alluvium) In addition, the retention ponds in the various drainages recharge the valley fill alluvium

The shallow system appears to be quite dynamic, with large water level changes in response to seasonal and other stresses Hurr (1976) describes the rapid response of water levels in wells completed in the Rocky Flats Alluvium to irrigation Similarly, there are several 1986 and 1987 wells which contain water during the spring months (April through June) which are dry in the late summer and fall

Ground-Water Flow Directions

Flow directions follow topography to the east and toward the drainages In addition, flow directions are controlled by the configuration of the top of bedrock beneath surficial materials The ground water in the drainages flows to the east in the valley fill materials and discharges as subsurface flow across the eastern Plant boundary during some portions of the year In addition, water in all of the surficial materials recharges the bedrock to small extent

3 4 2 Bedrock Flow Systems

The Denver ground-water basin underlies a 6,700 square mile area extending from the Front Range on the west to near Limon, Colorado on the east and from Greeley on the north to Colorado Springs on the south The four major bedrock units from deepest to shallowest are the Laramie-Fox Hills, the Arapahoe, the Denver, and the Dawson The Pierre Shale underlies these units and is considered the base of the Denver Basin bedrock aquifer system due to its great thickness (up to 8000 feet) and its low permeability (Robson and others, 1981a)

Presented below are discussions of the two Denver Basin bedrock aquifers which occur beneath Rocky Flats Plant - the Laramie-Fox Hills and the Arapahoe The Denver and Dawson do not occur in the vicinity of Rocky Flats Plant

Laramie-Fox Hills

The Laramie-Fox Hills Aquifer is composed of the upper sandstone and siltstone units of the Fox Hills Formation and the lower sandstone units of the

Laramie Formation The thickness of the aquifer ranges from zero near the aquifer boundaries to 200 to 300 feet near the center of the basin The upper Laramie coals and claystones separate the Laramie-Fox Hills sandstones from the overlying Arapahoe sandstones (Robson and others, 1981b)

On a regional scale ground-water in the Laramie-Fox Hills Aquifer flows from outcrop recharge areas toward the center of the basin and discharges to remote stream valleys Ground-water recharge from the overlying Araphoe to the Laramie-Fox Hills is negligible due to the thickness and low permeability of the upper Laramie claystone (Robson, 1987) Ground water discharges to pumping wells in the basin (Robson and others, 1981b) In the vicinity of Rocky Flats Plant ground-water flow is generally from the west to the east

<u>Arapahoe</u>

The Arapahoe Aquifer is defined as the saturated portion of the Arapahoe Formation by Robson and others (1981a) The Arapahoe Formation consists of a 400 to 700 foot thick sequence of interbedded claystones, siltstones, sandstones, and conglomerates with claystones and shale being more prominent in the northern third of the basin (Robson and others, 1981a) Individual sandstone beds are commonly lens shaped and range from a few inches to 30 to 40 feet in thickness (Robson and others, 1981a) Beneath the Plant the majority of ground-water flow in the Arapahoe is in the lenticular sandstones contained within the claystones (Rockwell International, 1986a)

There are two primary methods of recharge to the Arapahoe In outcrop and subcrop areas, it occurs from infiltration of incident precipitation and as infiltration of water from alluvial materials However, on a regional scale the primary recharge mechanism for the Arapahoe is leakage from the overlying Denver (Robson and others, 1981a)

Ground-water flow in the Arapahoe is from recharge areas at the edges of the basin toward discharge areas along incised stream valleys Ground-water is also discharged to pumping wells (Robson and others, 1981a) Ground-water flow in the vicinity of Rocky Flats Plant is from west to east toward the area of regional discharge along the South Platte River

3 5 SURFACE WATER HYDROLOGY

3 5 1 Natural Drainages

Three ephemeral streams drain the Rocky Flats Plant with flow generally from west to east (Figure 3-8) Rock Creek drains the northwestern corner and flows to the northeast in the buffer zone to its off-site confluence with Coal Creek

A topographic divide bisects the Plant The divide trends east-west and lies slightly south of Central Avenue (the approximate center line of the Plant site) An interceptor ditch lies between the Plant and the southern drainage Woman Creek The South Interceptor Ditch is tributary to the "C" Ponds Surface runoff downstream of the interceptor ditch is tributary to Woman Creek, which flows eastward to Standley Lake An irrigation ditch headgate located in the northeast quarter of the northwest quarter diverts water from Woman Creek and conveys it to a small reservoir known as Mower Reservoir North and South Walnut Creeks and an unnamed tributary drain the remainder of the Plant These three forks of Walnut Creek join in the buffer zone (approximately 0 7 miles downstream of the eastern edge of the Plant security area) and flow to Great Western Reservoir approximately one mile east of the confluence of the forks

3 5 2 Ditches and Diversions

The Church and McKay ditches cross the northern portion of the Plant Both carry water diverted from Coal Creek to Great Western Reservoir A diversion structure has been built in North Walnut Creek upstream of the Plant to divert McKay ditch out of the drainage The ditches parallel each other north of the present landfill and enter the Walnut Creek drainage downstream of the confluence of the north and south forks

In addition to the natural flows, there are six ditches in the general vicinity of the Plant The Church, McKay, and Kinnear Ditch and Reservoir Co Ditches (diversions of Coal Creek) cross the Plant Church Ditch delivers water to Upper Church Lake and Great Western Reservoir (City of Broomfield municipal water storage) McKay Ditch also supplies water to Great Western Reservoir Kinnear Ditch and Reservoir Co Ditch diverts water from Coal Creek and delivers it to Standley Lake (municipal water storage for the City of Westminster) via Woman Creek Woman Creek also delivers water to Mower Reservoir Last Chance Ditch flows south of the Plant and delivers water to Rocky Flats Lake and Twin Lakes Smart Ditch takes water from Rocky Flats Lake and transports it out of the area to the east The South Boulder Diversion Canal runs along the western upgradient edge of the Plant diverting water from South Boulder Creek and delivering it to Ralston Reservoir (City of Denver municipal water storage)

3 5 3 Retention Ponds and Plant Discharges

A series of dams, retention ponds, diversion structures, and ditches has been constructed at the Plant to control surface water and limit the potential for release of poor quality water

The ponds are located in the drainages of Walnut and Woman Creeks and are designated the A, B, and C series ponds Discharges from the downstream pond in each series are in accordance with the Plant's National Pollution Discharge Elimination System (NPDES) permit Ponds A-1 and A-2 are used only for spill control, and North Walnut Creek stream flow is diverted around them through an underground pipe Pond A-3 receives the North Walnut Creek stream flow and Plant runoff from the northern portion of the Plant Pond A-4 is designed for surface water control and for additional storage capacity for overflow from pond A-3

Five retention ponds are located along South Walnut Creek and are designated as B-1, B-2, B-3, B-4, and B-5, from west to east Ponds B-1 and B-2 are reserved for spill control, whereas pond B-3 receives treated effluent from the sanitary sewage treatment plant Ponds B-4 and B-5 receive surface runoff and occasionally collect discharge from pond B-3 Pond B-5 receives runoff from the central portion of the Plant and is used for surface water control in addition to collection of overflow from pond B-4

The two C series ponds, C-1 and C-2, are located along Woman Creek, south and east of the Plant, respectively Pond C-1 receives stream flow from Woman Creek This flow is diverted around pond C-2 into the Woman Creek channel downstream Pond C-2 receives surface runoff from the South Interceptor Ditch along the southern portion of the Plant Water in pond C-2 is discharged to Woman Creek in accordance with the Plant NPDES permit

There are many runoff control ditches within the Plant security area The largest of these is the Central Avenue Ditch which runs eastward along Central Avenue and discharges to South Walnut Creek (Pond B-5) The other major runoff control ditch is the South Interceptor Ditch which prevents runoff from the south side of the Plant from entering Woman Creek The ditch discharges to pond C-2, and Woman Creek is diverted around pond C-2 by a diversion structure just upstream of the pond

Another retention pond is located on the unnamed northern tributary of Walnut Creek, downstream of the present landfill Following water quality analyses, the water from the landfill pond is spray irrigated onto an area south of the landfill but upstream of the pond

The permit requires monitoring of specific parameters at seven discharge points The permitted discharges are

Discharge	Location
001	Pond B-3
002	Pond A-3
003	Reverse Osmosis Pilot Plant
004	Reverse Osmosis Plant
005	Pond A-4
006	Pond B-5
007	Pond C-2

The discharges from the ponds are regularly monitored to document compliance with NPDES permit requirements In addition to NPDES monitoring requirements, all discharges are monitored for plutonium, americium, uranium, and tritium concentrations

SECTION 4

SOIL CHARACTERIZATION

This section presents soil chemistry data from historical and recent investigations conducted at the West Spray Field The purpose of this section is to characterize the nature and extent of any soil contamination that resulted from spray application of liquids from the solar ponds The section begins with a summary of the characteristics of the solar pond and interceptor trench pump house (ITPH) liquids and sediments as this material is the source of any contamination present in the West Spray Field Appendix D contains the 1988 soils analytical data for the West Spray Field and Appendix E presents the pre-1988 analytical results for the West Spray Field and Buffer Zone soils, and the application liquids

4 1 APPLICATION LIQUIDS CHARACTERISTICS

The West Spray Field was used for spray application of excess liquids from solar pond 207B north and solar pond 207B central from April, 1982 to October, 1985 The majority of the liquid in the ponds came from the ITPH with pond 207B center also receiving some treated sanitary effluent To characterize the waste composition in these Solar Evaporation Ponds, numerous analyses of pond liquids have been conducted Table 4-1 summarizes two sets of metal analyses of Pond 207B North and Center liquids performed in October, 1984 and April, 1985 Table 4-2 summarizes weekly parameter monitoring of Ponds 207B North and Center liquids performed in 1984 and 1985 These weekly analyses were conducted prior to the spray application of the liquids to the West Spray Field and included the following parameters pH, Nitrate (as Nitrogen), Gross Alpha, and Gross Beta

TABLE 4-1

TWO SETS OF METAL ANALYSES OF PONDS 207-B NORTH AND CENTER LIQUIDS OCTOBER 1984 AND APRIL 1985

Element	Proposed Concentration Limit (mg/l)	Pond 207-B North (mg/l) 1984	Pond 207-B North (mg/l) 1985	Pond 207-B Center (mg/l) 1984	Pond 207-B Center (mg/l) 1985
Aluminum	5 0	1	0 16	2	0 15
Boron	NA	0 31	0 29	0 24	0 67
Calcium	NA	20 0	290	2 9	45 0
Cesium	0 02U	ND	ND	0 041	ND
Copper	1 0	ND	ND	0 016	0 37
Iron	0 3	0 28	0 29	0 2	0 74
Lead*	0 5	0 0035	ND	0 002	ND
Lithium	2 5	3 5	0 37	0 41	0 52
Manganese	0 05	ND	ND	0 081	0 022
Magnesium	NA	87 0	120	3 9	13 0
Molybdenum	0 1	0 0069	ND	0 016	0 037
Nickel	0 2	ND	ND	0 016	0 15
Phosphorous	NA	ND	ND	0 2	0 074
Potassium	NA	82 0	120 0	30 0	36 0
Selenium*	0 01	0 01	0 02	ND	ND
Silicon	NA	5 6	2 1	2 4	5 5
Silver*	0 05	ND	0 082	0 0016	0 015
Sodium	NA	370 0	620 00	67 0	250 00
Strontium	0 154	3 5	1 2	0 28	0 52
Tritium (pCi/l)	20000	0 069	ND	0 022	0 041
Vanadium	0 1	ND	ND	0 0081	ND
Zinc	5 0	ND	ND	0 041	ND
Zirconium	NA	ND	ND	0 0041	ND

ND = Not detected - Concentration below detection limit

* Denotes SDWA metal

Metals not detected· Antimony, Arsenic, Barium, Beryllium, Bismuth, Cadmium, Chromium, Cobalt, Germanium, Mercury, Niobium, Rubidium, Silicon, Tantalum, Tellurium, Thallium, Thorium, Tin, Uranium, Wolfram

---

Reference U S DOE, 1987, West Spray Field Sampling Plan Rocky Flats Plant, February 27, 1987

TABLE 4-2

SUMMARY OF WEEKLY PARAMETER MONITORING
PONDS 207-B NORTH AND CENTER LIQUIDS
1984 AND 1985

Analysis	Range	
	Pond 207-B North	Pond 207-B Center
pH	7.5-9.6	7.3-11.3
Nitrates (as N) (ppm)	335-1367 Average: 629 (0/71)	ND-15 6 Average: 4.7 (30/77)
Gross Alpha (pCi/l)	ND-323(33) Average: 144 (2/71)	ND-59(23) Average: 24 (45/77)
Gross Beta (pCi/l)	ND-163(25) Average: 63 (13/71)	ND-73(0) Average: 30 (60/77)

ND indicates less than detection limit or less than error limit.

Average presented is for reported concentrations greater than the detection limits

Values in parentheses indicate counting uncertainty.

Fraction represents number of non-detectable samples/total number of samples.

Reference: U.S. DOE, 1987, West Spray Field Sampling Plan, Rocky Flats Plant, February 27, 1987

In 1986, additional sampling of the liquids from Pond 207B North and the ITPH was conducted This field work was conducted as a result of the U S EPA request for information regarding active and inactive waste management units These samples were analyzed for metals (Table 4-3), radionuclides (Table 4-4), and volatile organic compounds (Table 4-5)

The data from the 1984 and 1985 sampling efforts suggest that the applied liquids contained low concentrations of metals Cesium, iron, lithium, manganese, selenium, silver, and strontium were each reported occasionally above the ground-water proposed concentration limit (Table 4-1) The samples also exhibited elevated levels of nitrates, gross alpha, and gross beta (Table 4-2) (See Section E-8 of the Post-Closure Care Permit for a discussion of the proposed concentration limits) In the samples collected from the ITPH and 207B Pond during the 1986 sampling, very few metals were identified above the detection limit (Table 4-3) Selenium was the only primary drinking water metal detected above the U S EPA Contract Laboratory Program (CLP) contract required detection limit (CRDL) Gross beta and uranium occurred in pond 207B north samples and in the ITPH liquid samples above the proposed concentration limit Plutonium, americium, gross alpha, and tritium were below the proposed concentration limits (Table 4-4)

Various volatile organic compounds were detected in the liquid samples from the 207B Ponds and the ITPH (Table 4-5) Methylene chloride was detected in all three samples collected from Pond 207B and ranged from 19 to 35 ug/l It was also detected in two of the samples analyzed from the ITPH (10 and 15 ug/l) However, methylene chloride was also present in the sampling blank at a concentration of 71 ug/l for the 207B samples and at 99 ug/l for the ITPH sampling blank, and therefore these detections appear to be the result of laboratory contamination Chloroform,

TABLE 4-3

SUMMARY OF LIQUIDS ANALYSIS
POND 207-B NORTH AND INTERCEPTOR TRENCH PUMP HOUSE (ITPH)
METALS DATA

Metal	Proposed Concentration Limits (ug/l)	Analytical Results (ug/l) Pond 207B	ITPH
Barium	1000	220	188-220
Calcium	NA	990-19800	240000-410000
Chromium	50	9	6-9
Copper	1000	6-14	5
Iron	300	20-90	100
Mercury	2	-	0 4-0 5
Magnesium	NA	407-72600	64000-100000
Manganese	50	15	5-13
Nickel	200	30-50	-
Potassium	NA	110-62700	38000-108000
Selenium	10	9	6-12
Silver	50	5-7	6-12
Sodium	NA	330-451000	270000-520000
Zinc	5000	11-22	24-80

NOTE Summary of results of metals based on values reported above the detection limit Ranges compiled from four samples collected in April, 1986, for Pond 207-B, ranges for ITPH from three samples collected April, 1986, 1 sample in 1987, and 2 samples in 1988

"-" Indicates concentration below detection limit

TABLE 4-4

RADIONUCLIDE DATA RANGE
ITPH AND POND 207-B NORTH

Radionuclide	ITPH Liquid * (pCi/l)	Pond 207-B North Liquor ** (pCi/l)	Proposed Concentration Limit (pCi/l)
Plutonium-239	0 05(0 08) - 0 84(0 40)	-0 03(0 06) - 0 01(0 06)	40
Americium-241	-0 01(0 03) - 0 02(0 05)	-0 02(0 04) - 0 08(0 08)	4
Uranium-233,234,238	42(5) - 110(4)	81(3) - 86(3)	40***
Gross Alpha (excluding Uranium)	-6(36) - 17(36)	-12(55) - 39(47)	15
Gross Beta	40(14) - 120(40)	-21(84) - 100(92)	50
Tritium	1600 - 3400	1200(300) - 1300(300)	20,000

* Based on 3 samples in 1986, 1 sample in 1987 and 2 samples in 1988

** Based on 3 samples in 1986

*** Total uranium

Values in parentheses indicate counting uncertainty

TABLE 4-5

VOLATILE COMPOUNDS ABOVE DETECTION LIMITS

SAMPLE TYPE	Sample No	Acetone	PCE	MECl	MEK	$CHCl_3$	CCl_4	TCE	Benzene	CS_2	Toluene	1 1 1-TCA	1 1,2-TCA
SOLAR POND 207B *													
Liquid (ug/l)	A1	-	-	28B	-	-	-	-	-	-	-	-	-
	B1	-	-	35B	-	-	-	-	-	-	-	-	-
	C1	-	-	19B	-	-	-	-	-	-	-	-	-
	Blank-01	-	-	71B	20	-	-	-	-	-	-	-	-
INTERCEPTOR TRENCH PUMP HOUSE **													
Sediments (ug/kg)	SA1	23	-	44B	-	-	-	-	-	-	-	-	-
	SB1	47	-	27B	-	-	-	2J	-	-	-	-	-
	Blank-510E	-	-	24	-	-	-	-	-	-	-	-	-
Liquids (ug/l)	LA1	-	-	-	-	3J	7	7	-	-	-	-	-
	LB1	-	-	10B	-	6	6	8	-	-	-	-	-
	LC1	-	-	14B	-	-	7	8	-	-	-	-	-
	Blank-L01	-	-	99B	110	-	-	-	-	-	-	-	-
	Wet-1	-	-	-	-	-	6	8	-	-	-	-	-
	SW88A084	-	-	-	-	-	-	-	-	-	-	-	-
	SW88A085	-	-	-	-	-	-	-	-	-	-	-	-
	SW88A086	-	-	1J	-	-	1J	-	-	-	-	-	-

* 1986 Data

** 1986 1987, and 1988 Data

Simple 01 - denotes blank analytical values
J = Estimated Value below the detection limit
B = Analyte was found in blank as well as the sample indicating possible blank contamination
-" = Value below detection limit

carbon tetrachloride, and trichloroethylene were volatile organic compounds reported at values above their detection limit and were not present in the sampling blank These compounds were present in the liquid samples collected from the ITPH Chloroform was present in two samples at 3 and 6 ug/l, carbon tetrachloride was found in three samples at 7, 6, and 7 ug/l, and trichloroethylene was detected in three samples at 7, 8, and 8 ug/l

In addition to the liquid sampling from the ITPH, two sediment samples were collected from the pump house during the 1986 investigation Calcium was the only metal significantly higher than the maximum background level (Table 4-5) The method for determining the background concentration ranges is discussed in Section 4 2 1 Methylene chloride was the only volatile organic compound detected in the ITPH sediments (27 and 44 ug/kg) (Table 4-6) It was also reported in the sampling blank at 24 ug/kg and is therefore considered to be laboratory artifact

No pesticides, or PCBs were found in the ITPH liquid and sediment samples Semi-volatiles were not found in the ITPH and 207B North liquids Nitrates and radionuclides were not analyzed for in the 1986 investigations

It is concluded that nitrate and uranium are the only constituents of the applied water that were consistently and significantly elevated relative to the proposed ground-water concentration limits Therefore these constituents should be the best indicators of soil (or ground-water) contamination that may have resulted from application of water at the West Spray Field

TABLE 4-6

**SUMMARY OF SEDIMENT ANALYSIS
FROM INTERCEPTOR PUMP HOUSE (ITPH)
METALS DATA 1986**

Metal	Maximum Background Concentration (mg/kg)	Analytical Results (mg/kg) ITPH Seds (4/23/86)	ITPH Seds (4/22/86)
Aluminum	9140	11600	10400
Calcium	2500U	10100	8290
Chromium	13	19	9
Copper	12U	17	15
Iron	12400	13200	8290
Lead	48	22	18
Magnesium	2500U	3050	2640
Manganese	337	242	197
Nickel	20U	22	23
Potassium	2500U	2750	2400
Sodium	2500U	550	497
Vanadium	38	33	26
Zinc	49	85	76

NOTE: Values above reported for metals concentrations above the detection limit.

4 2 SOIL CHEMISTRY

4 2 1 Background Soil Chemistry

Background metal and radionuclide concentrations in soils have been developed based on 1986 sampling and analysis in the west buffer zone (an area unaffected by spray application activities) (Figure 4-1) The top one foot of soil (Rocky Flats Alluvium) west of the West Spray Field was sampled Eighteen locations were pooled into three composite samples (consisting of six cores randomly selected) The sampling locations were chosen within a 400 foot diameter grid using a random number generating table At each location, a surface scrape was collected using a disposable plastic scoop In addition, two samples were collected from each location from 0-6 inches and 6-12 inches below ground surface using a split tube sampler driven with a sledge hammer to the desired depth Each sample interval from all of the sampling locations were then composited resulting in three composite samples from the three depths The same methodology was used for selecting the sampling locations within the West Spray Field in 1986 Table 4-7 presents a summary of the background soils data Sampling and analysis of soils from a single plot in the west buffer zone is not considered a complete characterization of background alluvial and bedrock materials, however, it serves as a basis for assessing potential contamination At the present time the soils data presented in Table 4-7 are the only background soils data available A plan is currently being developed to characterize the background soils, surface water, and ground water at the Rocky Flats Plant Table 4-8 lists the soil sampling parameters for the West Spray Field and Buffer Zone and Tables 4-9, 4-10, and 4-11 presents the analytical results for metals, radionuclides, and volatile organics, respectively

TABLE 4-7

METAL AND RADIONUCLIDE CONCENTRATIONS IN BACKGROUND SOIL

Metals	Concentration (mg/kg)
Aluminum	6,540 - 9,140
Antimony	41U
Arsenic	6 1U - 10
Barium	135U
Beryllium	3.4U
Calcium	2,500U
Cadmium	3.4U
Chromium (Total)	5 6 - 13
Cobalt	12U - 25
Copper	12U
Iron	9,080 - 12,400
Lead	15 - 48
Magnesium	2,500U
Manganese	196 -337
Mercury	0.1U
Nickel	20U
Potassium	2,500U
Selenium	3.4U
Silver	5U
Sodium	2,500U
Thallium	6.8U
Tin	41U
Vanadium	30U - 38
Zinc	20 -49

Radionuclides	Concentration (pCi/g)
Plutonium	0.01(0.10) - 0 10(0.20)
Americium	-0.02(0.03) - 0.28(0.16)
Uranium-233+234	0.66(0.16) - 1.4(0.20)
Uranium-238	0.62(0.16) - 1.2(0.2)
Tritium	-70(220) - 280(270)

NOTES: (1) Background values based on nine composite samples collected from the top one foot of Rocky Flats Alluvium in the West Buffer Zone
(2) "U" Indicates values less than detection limits
(3) Values in parentheses indicate counting uncertainty
(4) Tritium is in units of pCi/l of soil water

TABLE 4-8

1986 SOIL SAMPLING PARAMETERS
WEST SPRAY FIELD AND BUFFER ZONE

Organics

Target Compound List - Volatiles
Target Compound List - Semi-Volatiles*

Metals

Target Compound List-Metals

Radionuclides

Gross Alpha
Gross Beta
Plutonium-239
Americium-241
Uranium-233,-234
Uranium-238
Tritium

Other

RCRA Characteristics - Reactivity, Corrosivity (pH)
Ignitability
Total Cyanide
Hexavalent Chrome
Sulfide

TABLE 4-9

METALS ABOVE DETECTION LIMITS (1986 SOILS DATA)

METALS (mg/kg)		Al	Cr	Fe	Pb	Mn	Zn	V	Phenols	As	Co	Ca	Cu	Mg	Ni	K	Na
Maximum Background Concentration (mg/kg)		9140	13	12400	48	337	49	38	NA	10	25	2500U	12U	2500U	20U	2500U	2500U
WEST SPRAY FIELD																	
Surface Scrape	1D3	8330	11	10800	61	295	50*	-	-	9 2	[13]	[2060]	[11]	[1390]	20	[1840]	-
	2D3	7570	10	10400	63	337	52*	-	-	8 3	-	[2240]	[11]	[1340]	-	[1750]	-
	3D3	7670	9 6	9160	42	314	38	-	-	8 9	-	[1800]	[10]	[1230]	-	[1650]	[75]
0-6"	1E3	7390	8 6	9240	32	289	28	-	-	6 7	-	[1260]	[6 3]	[1090]	-	[1330]	-
	2E3	8760	9 4	12500	29	326	36	-	-	-	-	[1310]	[11]	[1240]	-	[1590]	-
	3E3	8420	12	9980	18	277	24	-	-	-	-	[1170]	[6 9]	[1040]	[19]	[1310]	-
6-12	1F3	7010	11	11300	15	240	26	-	-	6 1	-	[1070]	[7 3]	[922]	-	[1200]	-
	2F3	8920	6 8	9960	23	235	29	-	-	-	-	[1280]	[9 2]	[1150]	-	[1490]	[68]
	3F3	10600*	14*	10100	14	206	27	-	-	-	-	[1500]	[8 2]	[1310]	-	[1660]	-
BUFFER ZONE																	
Surface Scrape	1A3	8770	10	11000	38	272	41	-	-	-	-	[1840]	[9 6]	[1360]	-	[1700]	-
	2A3	9140	10	11400	48	337	49	-	-	6 8	-	[1930]	[9 7]	[1490]	[13]	[1860]	[217]
	3A3	9050	13	12300	42	286	44	-	-	-	-						
0-6"	1B3	8190	11	9080	31	274	33	-	-	-	-	[1660]	[6 9]	[1240]	[13]	[1390]	-
	2B3	6540	9	9610	29	247	29	-	-	7	[12]	[1320]	[8 4]	[997]	-	[1260]	-
	3B3	6740	5 7	9580	17	215	25	-	-	6 4	-	[1400]	[8 3]	[976]	[13]	[1190]	[68]
0-12'	1C3	8640	10	12400	19	293	23	38	0 5	-	[22]	[1100]	[6 6]	[1030]	[16]	[1100]	-
	2C3	7640	9 6	10200	16	196	30	-	-	-	-	[1400]	[9 1]	[1060]	[17]	[1250]	-
	3C3	7200	5 6	10900	15	285	20	-	-	-	25	[1020]	[9 9]	[883]	-	[951]	-

NOTE "- Indicates reported value below detection limit

Al Aluminum, Co = Cobalt, Fe = Iron, Mn = Manganese, Pb = Lead

As = Arsenic, Cr = Chromium, K = Potassium, Na = Sodium, V = Vanadium

Ca = Calcium, Cu = Copper, Mg = Magnesium, Ni = Nickel, Zn = Zinc

Brackets indicate value estimated below the detection limit

TABLE 4-10

RADIOCHEMICAL ANALYTES (1986 SOILS DATA)

	Sample Number	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Pu^{239} (pCi/g)	Am^{241} (pCi/g)	$U^{233,234}$ (pCi/g)	U^{238} (pCi/g)	H^3 (pCi/ml)
Maximum Background Concentration				0 10(0 20)	0 28(0 16)	1 4(0 20)	1 2(0 2)	0 280(0 270)
WEST SPRAY FIELD								
Surface Scrape	3D5	40(14)	34(6)	0 04(0 2)	0 02(0 06)	1 2 (0 2)	0 9 (0 2)	0 39(0 23)
	2D5	55(16)	37(6)	0 15(0 21)	0 01(0 06)	1 0 (0 2)	1 1 (0 2)	0 11(0 23)
	1D5	52(16)	40(6)	0 12(0 21)	0 01(0 05)	1 1 (0 2)	1 2 (0 2)	0 34(0 23)
0-6"	3E5	32(13)	29(6)	0 14(0 21)	0 04(0 06)	1 0 (0 2)	0 82(0 18)	0 11(0 23)
	2E5	43(14)	34(6)	0 03(0 19)	0 05(0 08)	0 74(0 18)	1 0 (0 2)	-0 09(0 22)
	1E5	44(15)	32(6)	0 07(0 20)	-0 02(0 03)	0 73(0 17)	0 80(0 18)	0 34(0 23)
6-12"	3F5	31(13)	29(6)	0 01(0 21)	-0 02(0 03)	0 83(0 19)	0 82(0 19)	0 21(0 23)
	2F5	20(11)	29(6)	0 04(0 20)	-0 02(0 03)	0 73(0 16)	0 84(0 20)	-0 08(0 22)
	1F5	21(11)	29(6)	-0 08(0 09)	-0 02(0 03)	0 59(0 13)	0 61(0 14)	0 54(0 24)
BUFFER ZONE								
Surface Scrape	1A5	67(17)	55(7)	0 10(0 20)	-0 02(0 03)	1 1 (0 2)	0 89(0 20)	0 09(0 23)
	2A5	71(18)	50(7)	0 02(0 10)	-0 02(0 03)	1 2 (0 2)	1 2 (0 2)	0 02(0 22)
	3A5	75(18)	56(7)	0 02(0 21)	0 02(0 05)	1 4 (0 2)	1 2 (0 2)	-0 05(0 22)
0-6'	1B5	46(15)	34(6)	0 01(0 10)	0 28(0 16)	0 77(0 17)	0 66(0 16)	-0 07(0 22)
	2B5	47(15)	40(7)	0 07(0 21)	0 02(0 06)	0 86(0 17)	0 92(0 18)	0 04(0 23)
	3B5	35(13)	30(6)	0 09(0 22)	0 0 (0 08)	0 89(0 19)	0 75(0 18)	0 20(0 23)
6-12"	1C5	18(11)	31(6)	0 05(0 21)	0 01(0 07)	0 67(0 17)	0 62(0 17)	0 13(0 23)
	2C5	36(13)	28(5)	0 03(0 21)	0 07(0 10)	0 67(0 15)	0 84(0 17)	0 08(0 23)
	3C5	37(14)	29(6)	0 05(0 21)	-0 02(0 03)	0 66(0 16)	0 76(0 18)	0 28(0 27)

67(17) - Number in parentheses represents error factor

TABLE 4-11

VOLATILE COMPOUNDS ABOVE DETECTION LIMITS (1986 SOILS DATA)

SAMPLE TYPE	Sample No	Acetone	PCE	MECl	MEK	$CHCl_3$	CCl_4	TCE	Benzene	CS_2	Toluene	1,1,1-TCA	1 1,2-TCA
WEST SPRAY FIELD SOILS													
Surface Scrape	1D1	-	-	36B	-	-	-	-	-	-	-	-	-
(ug/kg)	2D1	25B	-	29B	-	-	-	-	-	-	21	-	-
	3D1	-	-	34B	-	-	-	-	-	2BJ	2J	-	-
0-6" (ug/kg)	1E1	-	-	37B	-	2J	-	-	-	-	-	-	-
	2E1	14B	-	70B	-	-	-	-	-	-	-	-	-
	3E1	- J	-	33B	-	-	-	-	-	2BJ	43	-	-
6-12" (ug/kg)	1F1	-	-	33B	-	-	-	-	-	-	-	2J	2J
	2F1	-	-	33B	-	27	-	-	-	2J	7	-	-
	3F1	29	-	29B	-	-	-	-	-	2BJ	-	-	-
BUFFER ZONE SOILS													
Surface Scrape	1A1	-	-	-	-	-	-	-	-	-	1BJ	-	-
(ug/kg)	2A1	10B	-	-	-	-	-	-	-	-	1BJ	-	-
	3A1	10B	-	-	-	-	-	-	-	-	1BJ	-	-
0-6" (ug/kg)	1B1	-	-	46B	-	-	-	-	-	3BJ	-	-	-
	2B1	-	-	32B	-	-	-	-	-	2BJ	-	-	-
	3B1	-	-	32B	20	-	-	-	-	2BJ	-	-	-
6-12" (ug/kg)	1C1	130	-	39B	61	-	-	-	-	3BJ	3J	-	-
	2C1 NA	-	-	-	-	-	-	-	-	-	-	-	-
	3C1	71	-	28B	26	-	-	-	-	-	-	-	-
	A1	260J	-	-	-	-	-	-	-	-	-	-	-

J = Estimated Value below the detection limit
B = Analyte was found in blank as well as the sample indicating possible blank contamination
' = Value below detection limit

4 2 2 Site Soil Chemistry

Soil samples were collected during 1986 and 1988 to characterize the soil chemistry in the West Spray Field The 1986 field investigation included taking soil samples (one foot depth) from a plot in the West Spray Field Nine samples were collected (Table 4-9 through 4-11) The 1988 sampling program consisted of digging 12 test pits with a backhoe and collecting three soil samples for chemical analysis from each location at varying depths Table 4-12 lists the parameters for the samples collected within the test pits These parameters were chosen due to the nature of the operations at the Rocky Flats Facility and on the presence of certain analytes in the applied liquid waste and West Spray Field soils

As discussed herein, examination of the soil analyses indicates that the concentrations of nitrate, mercury, and plutonium are above estimated background concentrations in the West Spray Field soils Except for probable laboratory contamination of the samples, volatile organic compounds (VOC) were not detected in the 1988 test pit soil samples These general findings, including a discussion of laboratory contamination, are specifically addressed in this section

Metals

Soil samples from the West Spray Field test pits were analyzed for lead and mercury These metals were chosen because previous analyses had shown them to be present in the spray application liquids (See sampling plan for test pit sampling, Appendix A-1) The soil samples collected in the West Spray Field during the 1986 sampling were analyzed for the metals listed in Table 4-7 Mercury was not reported above background in any sample analyzed from the 1986 sampling effort However,

TABLE 4-12

1988 SOIL SAMPLING PARAMETERS
FOR TEST PITS
WEST SPRAY FIELD

<u>Organics</u>

Target Compound List - Volatiles Organics
Total Organic Carbon

<u>Radionuclides</u>

Gross Alpha
Gross Beta
Plutonium-239
Uranium-233
Uranium-234
Uranium-238

<u>Other</u>

Nitrates
Lead
Mercury
% Solids
Volatile Solids

mercury was present in six samples collected from the test pits (Table 4-13) above the background value of 0 1U (Table 4-7) The values ranged from 0 20 to 0 46 mg/kg In addition, eight samples exhibited concentrations above the background value of 0 1U (Table 4-7) but were estimated values since they were below the 881 Laboratory detection limit These values range from 0 12J to 0 18J (Table 4-13) Lead on the other hand was not reported above the maximum background concentration of 48 mg/kg in any sample from the test pits The only occurrences of lead above the maximum background standard were in two samples collected from the West Spray Field in the surface scrape samples Composite sample 1D3 contained a concentration of lead at 61 mg/kg and composite sample 2D3 contained 63 mg/kg This is unlikely to be significant as lead was not elevated in the water applied to the West Spray Field It is concluded that the soils are not contaminated with lead or mercury Although mercury consistently appeared in the 1988 soil samples above the background standard (0 1U), there does not seem to be a pattern relating the mercury concentrations to a particular depth or area since mercury was reported in all but two of the test pits and the depths from which the samples were collected ranged from 0 9 feet to 4 6 feet Furthermore, mercury randomly occurs in soil samples at these concentrations throughout the Plant site which appears to be indicative of natural background variations

Review of the additional metals data from the 1986 soil sampling effort, indicate slightly elevated concentrations of aluminum, chromium, and zinc (Table 4-9) Aluminum occurred in one sample (3F3) at a concentration of 10,600 mg/kg in the composite sample collected at 6-12 inches below ground surface Chromium (14 mg/kg) was also reported slightly above the maximum background value (13 mg/kg) in sample 3F3 Finally, zinc was found in two surface scrape composite samples (1D3

TABLE 4-13

METALS DETECTED ABOVE BACKGROUND VALUE IN TEST PIT SOILS WEST SPRAY FIELD 1988

Sample No	Depth (ft)	Lead (mg/kg)	Analyte Mercury (mg/kg)
WSF0102	2.2	-	0 46
WSF0204	4 4	-	0.17J
WSF0202	2.2	-	0.13J
WSF0201	0.9	-	0.18J
WSF0305	4.7	-	0.15J
WSF0404	4 1	-	0.12J
WSF0605	4.6	-	0.34
WSF0602	2.1	-	0.21
WSF0704	3.8	-	0.14J
WSF0702	2.0	-	0.17J
WSF0805	4.6	-	0.15J
WSF0902	2.0	-	0.20
WSF1004	3.5	-	0.34
WSF1102	2.0	-	0.23

NOTE: Background values established in West Spray Field Buffer Zone Table (4-1)
Lead (15-48 mg/kg)
Mercury (0 1 U)

"-" Denotes reported value below the background value.

J Denotes reported value estimated below the detection limit.

and 2D3) at 50 and 52 mg/kg All of these values are only slightly higher than their respective background concentrations and are therefore not considered to be contaminants of concern

It is concluded that natural variations in the soil chemistry could explain variability in soil metal concentrations in the West Spray Field None of the metals exhibit concentrations greater than twice the background values and therefore are not considered to be indicative of contamination

Radionuclides

Radionuclides are analyzed by counting particles randomly emitted during radioactive decay The rate of decay approaches some average rate for the material as the counting period increases Because actual samples are counted for finite periods of time, there will always be uncertainty associated with any measured value Radionuclide concentrations are thus reported as a measured value plus or minus a two standard deviation counting uncertainty (error term) This uncertainty is indicated in parentheses immediately following the measured value

A determination that two radionuclide concentrations are different from each other requires a statistical analysis incorporating the uncertainty However, radionuclide concentrations with error terms larger than their respective measured value are not considered statistically different from the background values shown in Table 4-9 because of the significant overlap of the probability distributions If the measured value for a radionuclide falls within the background measured range, it is not considered to be above background levels regardless of the error term This is the basis for stating within this report that radionuclide concentrations are within background ranges Similarly, if the measured value minus the error term of a sample is greater than the measured value plus the error term for the upper limit of the background range, it can be considered to be statistically different from background This leaves a range of measured values and error terms between these two extremes, where without a statistical analysis, it cannot be definitely stated whether the radionuclide concentration in the sample is different from background

Plutonium, americium, tritium and uranium concentrations in soil samples collected in 1986 from the West Spray Field and Buffer Zone met the above criteria for being below background concentrations

Plutonium were found above background in several of the 1988 test pit soil samples (Table 4-14) Plutonium concentrations were reported above background ranging in concentration from 0 37(0 06) to 0 59(0 06) pCi/g The highest concentrations are generally at the surface which indicates that plutonium was a constituent of the water applied in this area and was rapidly attenuated from further migration However, no soils at the West Spray Field exceed the EPA criterion of 20 pCi/g of plutonium These results appear to indicate uranium is not significantly elevated in the soils of the West Spray Field

Nitrate

Nitrate was not analyzed in the 1986 soil samples Soil samples collected from the test pits in 1988 however analyzed for nitrate (as nitrogen) Examination of the soil nitrate data (Table 4-15) indicates that most of the concentrations of nitrate in the samples were less than three times the detection limit (20 mg/kg) A total of five samples exhibited concentrations greater than 60 mg/kg These samples were WSF0704 (140 mg/kg), WSF0702 (150 mg/kg), WSF1002 (110 mg/kg), WSF1105 (80 mg/kg), and WSF1204 (420 mg/kg) Once again, there appears to be no distinct pattern correlating concentrations of nitrate with depth The samples containing the higher concentrations were collected from various depths within the pits

<u>Organic Laboratory Contamination of Soil</u>

The presence of Hazardous Substance List (HSL) organics in soil samples at concentrations above detection limits is indicative of contamination provided that these organics are not present in laboratory blanks associated with the samples

TABLE 4-14

SUMMARY OF RADIOCHEMISTRY RESULTS ABOVE BACKGROUND
WEST SPRAY FIELD TEST PIT SOIL SAMPLES 1988

Sample No	Depth (ft)	Analyte (pCi/g) $U^{233,234}$	U^{238}	$Pu^{239,240}$
WSF0101	1.0	-	-	0.59(0.06)
WSF0301	0.9	-	-	-
WSF0401	0.9	-	-	0.37(0.06)
WSF0402	2.5	-	-	-
WSF0404	4.1	-	-	-
WSF0501	0.75	-	-	-
WSF0502	2.0	-	-	-
WSF0704	3.8	-	-	-
WSF0801	0.65	-	-	0.50(0.06)
WSF0902	2.0	-	-	-
WSF1002	1.7	-	-	-
WSF1201	0.5	-	-	-

NOTE: Background values established in West Spray Field Buffer Zone (Table 4-1)
Uranium-233,-234 ($U^{233,234}$) 0.66(0.16)-1.4(0.20) pCi/g
Uranium-238 (U^{238}) 0.62(0.16)-1.2(0.2) pCi/g
Plutonium-239,-240 ($Pu^{239,240}$) 0.01(0.10)-0.10(0.20) pCi/g

Values in parentheses indicate counting uncertainty.

"-" Denotes reported value below the background value.

TABLE 4-15

CONCENTRATION OF NITRATE IN SOIL SAMPLES FROM WEST SPRAY FIELD TEST PITS 1988

Sample No	Depth (ft)	Nitrate as Nitrogen (mg/kg)
WSF0104	4 5	30
WSF0204	4.4	30
WSF0404	4.1	60
WSF0402	2.5	60
WSF0504	4.2	60
WSF0502	2 0	40
WSF0501	0.75	60
WSF0704	3.8	140
WSF0702	2.0	150
WSF1002	1.7	110
WSF1105	4 5	80
WSF1102	2.0	30
WSF1204	4.0	420

NOTE: Reported values for concentrations >20 mg/kg (detection limit)

However, the presence of an HSL organic in a laboratory blank and sample does not necessarily imply laboratory artifact, if the concentration in the sample greatly exceeded the laboratory blank concentration No analyses for laboratory blanks were included with the volatile organics analytical results for the 1986 soil samples and 1988 test pit soil samples Therefore, it is not possible to evaluate whether the detected concentrations of acetone, methylene chloride, trichloroethene, chloroform, carbon disulfide, toluene, 1,1,1-trichloroethane, and 1,1,2-trichloroethane are laboratory contaminants However, inspection of the data in Tables 4-11 and 4-16 indicate volatile organics are generally near or below detection limits In most cases, concentrations of the organic compounds are estimated below the detection limit It appears that organic contamination, although possible, is not of major significance in the West Spray Field Area

TABLE 4-16

VOLATILE COMPOUNDS ABOVE DETECTION LIMITS
1988 SOILS DATA
WEST SPRAY FIELD TEST PITS

Sample No.	Sample Depth (ft)	Acetone Value (ug/kg)	TCE Value (ug/kg)
WSF0402	2.5	16	-
WSF0404	4 1	78	-
WSF0501	0 75	7J	-
WSF0504	4.2	89	-
WSF0601	0 7	16	-
WSF0602	2 1	41	21
WSF0605	4.6	34	-
WSF0702	2.0	15	-
WSF0704	3.8	6J	-
WSF0801	0.65	5J	-
WSF0802	2.0	9J	-
WSF1105	4.5	33	-
WSF1201	0.5	-	23
WSF1202	2.0	30	-
WSF1204	4.0	6J	-

NOTE: Reported values for concentrations above the detection limit.

"-" Denotes reported value at the detection limit.

TCE=Trichloroethene

SECTION 5

SITE HYDROGEOLOGY

5 1 SITE GEOLOGY

Presented in this section are discussions on soils, hydrogeologic, and ground-water quality data collected during the 1986 and 1987 West Spray Field investigations The section begins with a detailed description of the soils (5 1 1), surficial (5 1 2), and bedrock (5 1 4) geology including lithologies, thicknesses, and extent of materials found at the West Spray Field Ground-water hydrology and water quality data are discussed in Section 5 2 1 and 5 2 2 for surficial and bedrock flow systems, respectively

Information for the discussion was obtained from previous studies, nine monitoring well borehole logs, 12 test pits, and field mapping Plate 5-1 shows the locations of all monitoring well locations at the Rocky Flats Plant, and Plate 5-2 presents monitoring well and test pit locations at the West Spray Field Geologic logs and well completion data sheets for monitoring wells and test pit geologic logs are presented in Appendix B and Appendix C, respectively Analytical data for soils and ground water are presented in Appendix D and Appendix E, respectively

5 1 1 Soils Descriptions

The soil in the West Spray Field is included in the Flatirons Soil series The Flatirons Soil is described as a deep, well drained, strongly developed soil composed of stony to gravelly and loamy material, and has been described by the Soil

Conservation Service in the 1983 Golden Area Soil Survey (United States Department of Agriculture, 1983) The soil occurs on high terraces and piedmonts The soil was formed in the Rocky Flats Alluvium, a calcareous, gravelly, cobbly and loamy material Permeability of the soil is slow and runoff erosion is not considered a hazard

Based on test pit logs, the A soil horizons at the West Spray Field range from 1 1 feet (WSF03, WSF06, WSF08, WSF09) to 1 35 feet (WSF04) in thickness Plate 5-3 presents a fence diagram illustrating the soil zones within the test pits at the West Spray Field This surface and upper part of the B horizon is described as dusky brown (5 YR 2/2) [Geological Society of America - Rock Color Chart, 1984] gravelly, cobbly, sandy loam that is moist to wet The zone is typically poorly to moderately sorted with subrounded and subangular fine-graded to coarse-graded (Grain Size Scale - American Geological Institute, 1982) gravels with occasional small cobbles Sand is very fine-grained to trace medium-grained The contact with the B horizon is wavy and sharp

The B horizon extends from 1 1 feet (WSF03, WSF06, WSF08, WSF09) to 3 5 feet in depth below ground surface (WSF01, WSF06, WSF07) (Plate 5-3) This subsoil is a moderate brown (5 YR 4/4) gravelly, sandy loam to sandy loam and gravel with small zones of intense red and brown staining indicative of weathering Sand is generally moderately sorted, subangular to subrounded, medium-grained to coarse-grained with occasional fine-grained pockets Gravels are described as subrounded, fine-graded to very coarse-graded pebbles and small to large cobbles with occasional small boulders The gravels and sands are indicative of a short transport distance Clay occurs in the matrix but mostly in pockets associated with the gravel The zone is generally moist to saturated Some organic soil stringers from the A horizon above were noted in

WSF02, WSF03, WSF04, WSF05, and WSF06 The contact into the C horizon is irregular and gradational and occurs from 3 0 feet to 3 5 feet in depth (Plate 5-3)

The C horizons extend from 2 5 feet (WSF03) to 5 2 feet (WSF01) in depth This zone consists of sandy loam or clayey loam and gravel or gravelly sandy loam Colors range from light brown (5 YR 5/6) to moderate yellowish brown (10 YR 5/4) with zones of red, brown orange or yellow staining The sand is typically medium-grained, subangular to subrounded, moderately sorted, with some fine-grained and coarse-grained sands Gravels are subrounded, moderately to poorly sorted, fine-grained pebbles to large cobbles with occasional small boulders Clay zones of olive gray are commonly associated with the gravel and cobbles The zone is generally moist with occasional saturated zones Caliche stringers were encountered at 4 4 feet in WSF06 just above a saturated zone

5 1 2 Surficial Geology

The West Spray Field Area, a pediment surface with little topographic relief and gentle slope to the east, is capped by Rocky Flats Alluvium unconformably overlying the Laramie Formation Plate 5-4 presents the distribution of surficial materials based on interpretation of field mapping and borehole logs

5 1 3 Rocky Flats Alluvium

The Quaternary Rocky Flats Alluvium is the oldest and topographically highest alluvial deposit at the Rocky Flats Plant It is Nebraskan in age (Scott, 1965) and is situated at an elevation of approximately 5,950 to 6,000 feet above mean sea level at the West Spray Field The Rocky Flats Alluvium is a series of coalescing alluvial fans deposited by braided streams (Hurr, 1976) The erosional surface (pediment) on which the alluvium was deposited slopes gently eastward truncating the Laramie Formation at the West Spray Field

The Rocky Flats Alluvium in the West Spray Field Area is described as a generally poorly sorted, unconsolidated deposit of gravel, cobbles, and boulders with clay, silt, and sand Colors of the alluvium range from moderate yellowish brown (10 YR 5/4) [Geological Society of America - Rock Color Chart, 1984] to moderate brown (5 YR 4/4), In addition, shades of various browns, reds, olives, and grays are interspersed throughout

The quartzite and granitic gravels, pebbles, cobbles, and boulders, predominant in the Rocky Flats Alluvium are poorly sorted and subangular to subrounded These characteristics are indicative of materials transported short distances Zones of sand, silt, and clay are interspersed throughout the gravels and cobbles

The grain size of the quartz and granitic sand encountered ranges from occasional fine-grained to mostly medium-grained to coarse-grained The sandy zones range in thickness from 0 5 feet (49-86) to 14 feet (48-86)

Cross sections A-A', B-B', and C-C' (Plate 5-4) illustrate the Rocky Flats Alluvium overlying the Laramie Formation In the well pair 51-86 and 52-86 (cross section A-A'), thin silt and sand stringers within the Rocky Flats Alluvium can be correlated In addition, a thin sand lens within the gravels can be seen in well 48-86 (46-60 feet) Well 49-86, however, contained a sand lens only one foot thick at 49 feet below ground surface This pinching-out sand lens may be evidence of a cut and fill channel deposit which would be characteristic of braided stream depositional features

Finally, cross section C-C' shows the thinning of the Rocky Flats Alluvium to the northeast The total thickness decreases from 98 feet thick in well 50-86 to 47 feet in well 45-86

5 1 4 Bedrock Geology

The Cretaceous Laramie Formation underlies surficial materials at the West Spray Field Steeply dipping beds of the Fox Hills Sandstone and Laramie Formation are found west of the West Spray Field These relatively steep dips are found near the axis of the syncline flanking the Front Range uplift During field mapping of the West Spray Field area in 1986, strike and dips were collected from Laramie Formation outcrops west of the Plant in the clay pits The measured dip angles ranged between 42 and 45 degrees with a dip direction of approximately N 80^{O}E Three wells were completed in various zones of the bedrock during the 1986 drilling program

The Laramie Formation is a fluvial sequence of sandstones, siltstones, claystones, and coals, which is subdivided into two major lithologic units a lower sandstone unit and an upper claystone unit The lower sandstone unit is exposed in clay pits west of the Plant, and the upper claystone unit was observed in outcrop and in cores of several 1986 monitor wells west of the Plant

The Laramie Formation in the West Spray Field area consists of claystone with occasional zones of interbedded siltstones and sandstones Contacts between various lithologies are both gradational and sharp

5 1 4 1 Laramie Formation Claystones

Claystone was the most frequently encountered lithology of the Laramie Formation immediately below the Quaternary/Cretaceous contact (Plate 5-5) The claystones are massive and blocky and occasionally contain interbeds of sands and silt

Weathered bedrock was encountered directly beneath surficial materials in all the monitoring wells during previous investigations Weathering penetrates approximately 31 feet (well 46-86) to 61 feet (well 52-86) into bedrock The weathered claystones generally range from light olive gray (5 Y 5/2) to medium light gray (N 6/0) and medium gray (N 5/0) with moderate oxide staining of dark yellowish orange (10 YR 6/6) Stains may occur as banding or mottling Occasional zones of sandstone or siltstone interbeds up to 0 5 ft thick were encountered Iron oxide concretions, wood fragments, organic fragments, and abundant fractures with associated limonite stains were noted in wells 46-86, 48-86, and 52-86 In well 48-86 a zone of ironstone concretions was encountered from 81 2 to 82 2 feet

Unweathered claystone was encountered only in well 48-86 from 121 5 feet to 126 9 feet and again at 131 5 feet to 141 5 feet below ground surface The claystone is medium dark gray (N 4/0) with a trace of silt and has very fine-grained sand beds approximately 0 5 feet thick from 136 5 feet to 141 5 feet A calcite filled fracture in the claystone occurred in the zone from 126 5 to 126 9 feet Between the two zones of claystone a 4 6-foot thick bed of sandstone was encountered

5 1 4 2 Laramie Formation Siltstones

Bedrock well 46-86 is completed in Laramie Formation siltstone (Cross Section B-B', Plate 5-3) In addition wells 45-86, 46-86, 48-86, 49-86, 51-86, and 52-86 encountered shallow siltstones These siltstones range from 1 0 feet (49-86) to 43 0 feet (48-86) in thickness The siltstones are also encountered as thin sandy siltstones or clayey siltstone interbeds in claystone and sandstone zones

Weathered siltstone is typically medium light gray (N 6/0) to light olive gray (5 Y 5/2) with stains and mottles of dark yellowish orange (10 YR 6/6) Bed thickness ranges from approximately one to eight feet with sandy siltstone or clayey siltstone interbeds one to three inches thick Iron nodules are occasional and fractures abundant from 99 to 104 feet in well 48-86 and from 133 to 136 feet in well 52-86

Unweathered siltstone is typically medium light gray (N 6/0) to medium dark gray (N 4/0) and has approximately 0 25-foot thick beds of sandstones or claystone Bedding is convoluted and massive Coal occurs occasionally and carbonaceous fragments are abundant

5 1 4 3 Laramie Formation Sandstones

Bedrock wells 48-86 and 52-86 are completed in Laramie Formation Sandstones with some interbedded siltstone zones Sandstones range from 0 8 feet (48-86) to 27 feet (52-86) in thickness (cross section A-A', Plate 5-5) Weathered sandstone was encountered in well 52-86, varying from light gray (N 7/0) to yellowish gray (5 Y 7/2) with dark yellowish orange (10 YR 6/6) staining or mottling The sandstone is generally composed of very fine-grained to medium-grained quartz sand with silica cementation Silty sandstone and clayey sandstone is common Siltstone/sandstone interbeds 0 3 to 0 8 feet thick, crossbedding, and cut and fill structures were encountered from 118 to 123 feet in well 52-86 Bedding planes dipping 60-70^{0} and 35-40^{0} off horizontal were also encountered from 111 to 118 feet and 118 to 123 feet in well 52-86, respectively

Unweathered sandstone was encountered in 46-86 and 48-86 ranging in thickness from 0 7 to 11 feet These sandstones are generally composed of moderately to poorly sorted, very fine-grained to medium-grained sand commonly with calcite cementation Convoluted bedding and crossbedding is common, flaser bedding characteristics were noted in 48-86 The sandstone may be silty or clayey with occasional thin laminae of fine silt and clay The sandstone color typically ranged from medium light gray (N 6/0) to medium dark gray (N 4/0) The thin sandstone bed in well 46-86 at 126 9 to 127 6 feet was additionally described as dark greenish gray (5 GY 4/1) in color Unweathered sandstone in well 48-86 occurred at 151 3 to 153 feet and again at 197 to 208 3 feet Cross sections A-A' through C-C' reflect the assumed 42 degree structural dip for the West Spray Field Area (Plate 5-5)

5 2 GROUND-WATER HYDROLOGY

Ground water occurs in Rocky Flats Alluvium and the underlying Laramie Formation Ground-water flow in Rocky Flats Alluvium is unconfined, confined ground-water flow exists in the Laramie Formation sandstones These two hydraulically connected flow systems are discussed separately below

5 2 1 Ground-water System in Rocky Flats Alluvium

5 2 1 1 Recharge/Discharge Conditions

Recharge to the water table occurs as infiltration of incident precipitation In addition, ground water within Rocky Flats Alluvium flows eastward into the West Spray Field Area

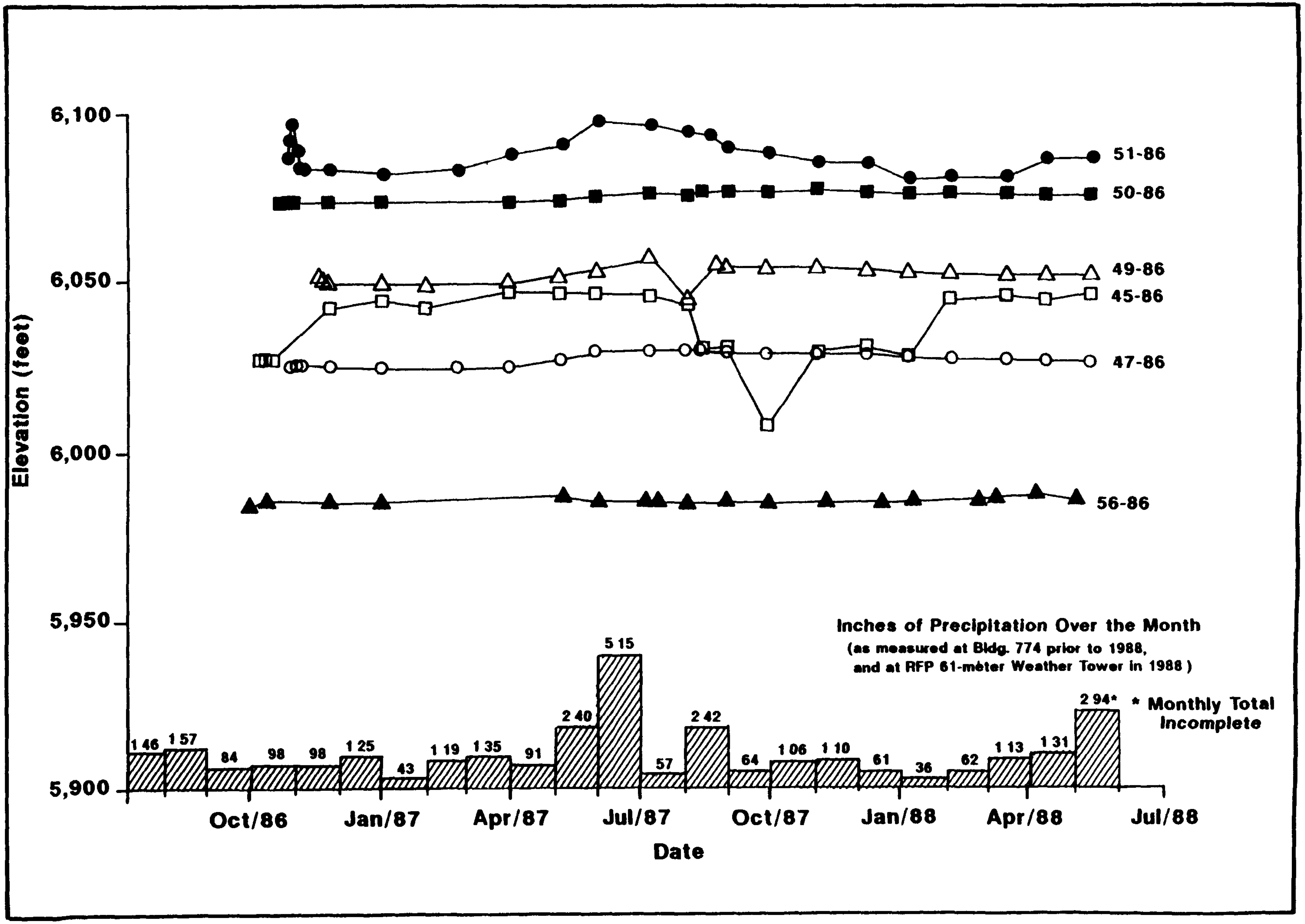
Ground-water discharge from the West Spray Field Area occurs as evapotranspiration, as eastward flow within the Rocky Flats Alluvium, and as seepage into Woman Creek to the south and into North Walnut Creek to the east-northeast

The surficial ground-water flow system is quite dynamic, with large water level changes occurring in response to precipitation events and to stream and ditch flow Hurr (1976) describes the rapid response of water levels in wells completed in Rocky Flats Alluvium to irrigation

In Figure 5-1 water table elevation data in the West Spray Field area are compared through time with the monthly precipitation measured at the 774 Building and the 61-meter weather tower at the Rocky Flats Plant A general correlation appears to exist between precipitation and water-level data for wells 47-86, 49-86, and 51-86

Figu.. 5-1:

WEST SPRAY FIELD: ELEVATION OF THE WATER TABLE AND MONTHLY PRECIPITATION



5 2 1 2 Ground-water Flow

In the West Spray Field area, ground water flows east-northeastwardly following the regional topography of the Rocky Flats Alluvium Locally in the vicinity of the drainage system of Woman Creek, ground water flows southeastwardly into this drainage system

This general pattern of ground-water flow is evidenced by the water-table maps constructed for May, June, August, and November, 1987 and April 1988 (Plates 5-6 through 5-10, respectively) Seasonal variations in ground-water flow appear to be related to the overall elevation of the water table When the water-table is relatively high, May, June and August 1987 (Plates 5-6, 5-7, 5-8) ground-water flow is more eastwardly than in periods when the water table is lower, November 1987 and April 1988 (Plates 5-9, 5-10)

The water table elevations recorded at monitor well 47-86 are generally low with respect to the overall water table An exception is the water table of November 1987 (Plate 5-9), where water-table elevations in monitor wells 47-86 and 45-86 are very similar and imply north-northeastward ground-water flow in the northeast corner of the study area

The water-level elevation of the raw-water supply pond located south of monitor well 49-86 was not used in the construction of the water-table maps This pond is lined and consequently not hydraulically connected with the ground-water system in the Rocky Flats Alluvium

5 2 1 3 Hydraulic Conductivities

Hydraulic conductivity values were developed for surficial materials from drawdown-recovery and slug tests performed on 1986 wells Drawdown-recovery tests were analyzed using the Residual Drawdown Plot (Driscoll, 1986) and the method of Bouwer (1978), and slug tests were analyzed by the method of Bouwer and Rice (1976) Results of these tests are summarized in Table 5-1 Test data and analyses are presented in Appendix B

The hydraulic conductivity values calculated for the Rocky Flats Alluvium at the West Spray Field area ranged from $2\,1 \times 10^{-5}$ centimeters per second (cm/s) to $5\,3 \times 10^{-4}$ cm/s These values correspond to horizontal ground-water flow velocities of 6 9 to 175 feet per year (ft/yr), respectively See Table 5-1 for details

5 2 1 4 Basis for Ground-Water Quality Assessment

The assessment provided here is qualitative in nature, its purpose being the identification of obvious impacts of the West Spray Field on ground-water quality The reader is referred to Section E of the Post-Closure Care Permit Application for a discussion of proposed monitoring to achieve compliance with 40 CFR Part 264 Subpart F Although the current monitoring program at the West Spray Field was not designed specifically to satisfy RCRA requirements, many of the analytes measured are those required for routine monitoring under 265 92(b) and assessment monitoring

TABLE 5-1

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS IN ROCKY FLATS ALLUVIUM

Well	Lithology	Hydraulic Conductivities Drawdown Recovery Test (cm/s)	Slug Test (cm/s)	Ground Water Velocity* (ft/yr)
45-86	Gravel, sand, silt		2.1×10^{-5}	6.9
47-86	Gravel, silt	2.6×10^{-5}		8.6
49-86	Gravel, sand, silt		9.7×10^{-5}	32
50-86	Gravel, sand, silt		5.3×10^{-4}	175
56-86	Boulders + Silt		5.0×10^{-5}	17
	Geometric Mean (cm/s)			
	Gravel:	2.6×10^{-5}	1.0×10^{-4}	8.6, 33
	Boulders + Silt		5.0×10^{-5}	17

* Horizontal ground-water velocity. Velocities are calculated from the hydraulic conductivity, the average horizontal gradient of 0.033 ft/ft, and an assumed effective porosity of 0.1 The equation used is

G-W Velocity (ft/yr) = K(1.0×10^{6} ft-sec/cm-yr)(0.033 ft/ft)/(0.1)

where K = hydraulic conductivity (cm/s)

under 265 93(a) Parameters for routine monitoring included in the monitoring program are the Safe Drinking Water Act (SDWA) metals, chloride, iron, manganese, sodium, sulfate, pH, and specific conductance Assessment monitoring parameters are Appendix IX hazardous waste constituents expected in the unit Many of the Hazardous Substances List (HSL) volatiles are Appendix IX hazardous waste constituents that may have been in the ground water collected at the solar ponds and subsequently released to the West Spray Field The radionuclides, although not Appendix IX hazardous waste constituents, have been analyzed because they are constituents of the waste disposed at the solar ponds and potentially released to the West Spray Field Other parameters analyzed are for general inorganic characterization of the ground water

A ground-water protection standard (concentration limit) is not defined for interim status regulated units under 40 CFR 265, however, regulations at 40 CFR 264 Subpart F have been used as a framework to examine the ground-water quality at the West Spray Field The ground-water protection standard defined in 40 CFR 264 94 specifies background levels for Appendix IX hazardous constituents or SDWA drinking water standards for the SDWA metals (which are also Appendix IX hazardous constituents) The SDWA drinking water standards, as well as standards for other metals, inorganics, and radionuclides which are not hazardous constituents are shown in Table 5-2 The concentrations for major ions and non-SDWA metals are the Colorado Department of Health (CDH) ground-water standards for protection of human health (or protection of agriculture if human health standards are not available) The plutonium and americium concentrations are proposed drinking water standards (51 FR 34859) The uranium concentration is a CDH surface water

TABLE 5-2

BACKGROUND ALLUVIAL GROUND-WATER QUALITY AND PROPOSED GROUND-WATER CONCENTRATION LIMITS

	Element	Concentration Range (mg/l) Background*	Proposed Ground-water Concentration Limits
METALS			
	Aluminum	029U- 22	5 0
++	Antimony	02U	0 02U
+	Arsenic	005U	0 05
+	Barium	048-0 071	1 0
++	Beryllium	005U-0 011	0 011
+	Cadmium	005U	0 01
	Cesium	02U	0 02U**
+	Chromium	01U	0 05
++	Cobalt	022U	0 022U
++	Copper	0063U- 012	0 012
	Iron	0069U- 125	0 3
+	Lead	005U- 010	0 05
++	Lithium	1U	0 1U
	Manganese	005U- 066	0 05
+	Mercury	0002U	0 002
	Molybdenum	022U	0 1
++	Nickel	037U	0 037U
+	Selenium	005U	0 01
+	Silver	0076U	0 05
	Strontium	11- 16	0 16
++	Thallium	01U	0 01U**
++	Vanadium	024U	0 024U
++	Zinc	02U- 086	0 086
RADIONUCLIDES		Concentration Range (pci/l)	
	Gross Alpha	Below MDA-262(34)	15
	Gross Beta	Below MDA-135(26)	50
	Uranium 233,234	Below MDA-1 5(0 9)	40 ***
	Uranium 235	Below MDA	40 ***
	Uranium 238	Below MDA-2 2(0 8)	40 ***
	Plutonium 239,240	Below MDA	40
	Americium 241	Below MDA	4
	Strontium 89,90	Below 3 32	8
	Tritium	Below 593	20,000

TABLE 5-2
(CONTINUED)
BACKGROUND ALLUVIAL
GROUND-WATER QUALITY
AND PROPOSED GROUND-WATER QUALITY CONCENTRATION LIMITS

	Element	Concentration Range (mg/l) Background*	Proposed Ground-water Concentration Limits
MAJOR IONS			
	Calcium	22-34	NA
	Magnesium	3 6-5 9	NA
	Potassium	70-4 70	NA
	Sodium	8-13	NA
	Bicarbonate	73-80	NA
	Carbonate	ND	NA
	Chloride	6-19	250
	Nitrate	80-1 5	10
	Sulfate	15-27	250
	Total Dissolved Solids	134-167	400

* Well 55-86
*** Total Uranium
\+ SDWA metal and Appendix IX hazardous constituent
++ Appendix IX hazardous constituent that is not an SDWA metal
NA Not available
MDA Theoretical Minimum Detectable Activity
U Values less than Detection Limits
ND Non-Detectable

standard [5 CCR 1002-8, Section 3 8 5(3)] All other radionuclide standards are SDWA maximum contaminant levels These analyte concentrations are proposed concentration limits and are used to preliminarily assess the public health significance of the ground-water quality

Table 5-3 lists the analyses performed on the ground-water samples All analytical data are presented in Appendix D and Table 5-4 summarizes the available ground-water quality data discussed in this report

5 2 1 5 Alluvial Ground-Water Quality

Basis for Background Alluvial Ground-Water Quality Assessment

Background conditions are characterized in this document from alluvial well 55-86 Well 55-86 is completed in Rocky Flats Alluvium south of the West Spray Field in an area unimpacted by any waste management units (Plate 5-1) Because of the presence of high nitrate in ground water at the immediately upgradient wells 10-81 and 51-86, these wells cannot be used as a basis for characterizing alluvial ground water upgradient of the West Spray Field Well 7-82, also immediately upgradient, has had insufficient water in the well for analysis since well completion The presence of nitrate indicates the wind potentially blew the spray in a westerly, upgradient direction or that the dewatering and/or increased evaporation from the nearby gravel and/or clay pits changed the local ground-water flow toward a more westerly direction

TABLE 5-3
GROUND-WATER SAMPLING PARAMETERS

FIELD PARAMETERS
pH
Specific Conductance
Temperature

INDICATORS
Total Dissolved Solids

METALS**
Target Compound List - Metals
Molybdenum
Strontium
Chromium (hexavalent)
Lithium

ANIONS
Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate

ORGANICS
Target Compound List - Volatiles***
Oil and Grease

RADIONUCLIDES
Gross Alpha
Gross Beta
Uranium 233, 234, 235, and 238
Americium 241
Plutonium 239
Strontium 90
Cesium 137
Tritium

** Dissolved metals

*** Ground-water samples from the first, second, and third quarters of 1987, and all surface water samples were analyzed by the Rockwell 881 Laboratory for only 9 of the HSL volatiles These volatiles are the chlorinated solvents historically detected in the ground water and are as follows PCE, TCE, 1,1-DCE, 1,2-DCA, t-1,2-DCE, 1,1,1-TCA, 1,1,2-TCA, CCl_4 and $CHCl_3$ Ground-water samples from fourth quarter 1987 and first quarter 1988 were analyzed for HSL volatiles with the exception of 2-chloroethylvinyl ether

Table 5-4

Groundwater Sample Information

for Regulated Units at Rocky Flats Plant

SAMPLE INFORMATION				FIELD PARAMETERS				LABORATORY BATCH NUMBERS			
WELL NUMBER	NUMBER	DATE	TYPE	pH	CONDUCT (umho/cm)	TEMP (deg C)	SPEC COND (umho/cm)	VOLATILE ORGANICS	METALS	INORGANICS	RADIOCHEMISTRY
West Spray Field Alluvial Wells											
0881	6088108860	08/18/86	Routine	8 00	370	17 0	429	8608 036 002	8608 036 003	8608 036 004	1000 000 739
0881	8 81 05-14 87	05/14/87	Routine					0187 881 102	0187 881 102	0187 881 105	0187 881 107
0881	8 81 06 23 87	06/23/87	Routine					0287 881 062	0287 881 062	0287 881 066	0287 881 062
0881	8 81 08 18 87	08/18/87	Routine	8 30	283	14 0	345	0387 881 086	0387 881 093	0387 881 092	0387 881 071
0881	8 81 01 14 88	01/14 88	Routine	7 90	314	10 9	403	0487 881 090	0487 881 116	0487 881 076	0487 881 076
0881	8 81 01 14 88	01/14/88	Routine					Insufficient Sample	Insufficient Sample	0487 881 076	Insufficient Sample
0981	6098108860	08/14/86	Routine	9 00	285	14 0	288	8608 029 049	8608 029 051	8608 029 052	1000 000 245
0981	9 81 05 19 87	05/19/87	Routine					0187 881 107	0187 881 107	0187 881 111	0187 881 113
0981	9 81 06 23 87	06/23/87	Routine					0287 881 063	0287 881 063	0287 881 067	0287 881 063
0981	9 81 08 18 87	08/18/87	Routine	8 10	361	18 5	408	0387 881 087	0387 881 094	0387 881 091	0387 881 070
0981	9 81 01 13 88	01/13/88	Routine	9 00	367	11 9	463	0487 881 097	0487 881 079	0487 881 075	0487 881 075
1081	6108108860	08/08/86	Routine					8608 014 007	8608 014 009	8608 014 010	1000 000 247
1081	10 81 05 11 87	05/11/87	Routine					0187 881 089	0187 881 089	0187 881 088	0187 881 089
1081	10 81 06 18 87	06/18/87	Routine					0287 881 052	0287 881 052	0287 881 054	0287 881 052
1081	10 81 08 21 87	08/21/87	Routine	7 00	100	16 4	117	0387 881 091	0387 881 102	0387 881 090	0387 881 077
1081	10 818 08 21 87	08/21/87	Field Duplicate						0387 881 103	0387 881 099	0387 881 078
1081	10 81 01 12 88	01/12/88	Routine	7 00	225	12 2	283	0487 881 095	0487 881 073	0487 881 073	0487 881 018
1081	10 81 02 04 88	02/04/88	Routine	8 40	191	10 1	248	0188 881 100	0188 881 100	0188 881 100	0188 881 100
0582	6058208860	08/13/86	Routine	5 60	320	13 0	352	8608 027 023	8608 027 024	8608 027 025	1000 000 230
0582	5 82 05 13 87	05/13/87	Routine					0187 881 094	0187 881 094	0187 881 094	0187 881 097
0582	5 82 06 18 87	06/18/87	Routine					0287 881 056	0287 881 056	0287 881 053	0287 881 056
0582	5 82 09 17 87	09/17/87	Routine	6 40	310	16 9	360	0387 881 112	0387 881 120	0387 881 114	0387 881 097
0582	5 82 01 07 88	01/07/88	Routine	6 40	279	9 8	364	0487 881 084	0487 881 075	0487 881 070	0487 881 070
0682	6068208860	08/18/86	Routine	7 50	140	17 0	162	8608 036 026	8608 036 027	8608 036 028	1000 000 235
0682	6 82 05 12 87	05/12/87	Routine					0187 881 092	0187 881 092	0187 881 093	0187 881 096
0682	6 82 06 18 87	06/18/87	Routine					0287 881 055	0287 881 055	0287 881 059	0287 881 055
0682	6 82 08 18 87	08/18/87	Routine	7 20	136	13 9	166	0387 881 088	0387 881 096	0387 881 094	0387 881 073
0682	6 82 01 07 88	01/07/88	Routine	7 20	79	8 8	105	0487 881 083	0487 881 076	0487 881 069	0487 881 071
0782	7 82 05 11 87	05/11/87	Routine					0187 881 127			
0782	DRY	08/20/87									
0782	DRY	12/05/87									
0782	07 82 02 04 88	02/04/88	Routine					0188 881 101	Insufficient Sample	Insufficient Sample	Insufficient Sample
4586	6458610860	10/16/86	Routine	6 70	240	12 0	302	8610 044 004	8610 044 007	8610 044 008	1000 000 287
4586	6458610862	10/16/86	Field Duplicate	6 70	220	12 0	277	8610-044 016	8610 044 017	8610 044 018	1000 000 289
4586	45 86 05 15 87	05/14/87	Routine	6 40	91	12 0	115	0187 881 090	0187 881 098	0187 881 106	0187 881 108
4586	45 86 06 12 87	06/12/87	Routine	6 50	114	14 7	137	0287 881 043	0287 881 043	0287 881 046	0287 881 043
4586	45 86 08 14 87	08/14/87	Routine	5 80	87	12 1	109	0387 881 084	0387 881 089	0387 881 087	0387 881 065
4586	45 86 09 30 87	09/30/87	Field Split					8710 006 0050	No Sample	No Sample	No Sample
4586	45 86 09 30 87	09/30/87	Routine	6 90	105	15 3	125	0487 881 001	0487 881 005	0487 881 001	0487 881 020
4586	45 86 10 01 87	10/01/87	Field Split					No Sample	No Sample	No Sample	0187 123 013
4786	6478611860	11/07/86	Routine	6 50	72	10 0	95	8611 014 001	8611 014 002	8611 014 003	1000 000 290
4786	6478611862	11/07/86	Field Duplicate	6 50	72	10 0	95	8611 014 006	8611 014 007	8611 014 008	1000 000 292
4786	47 86 05 13 87	05/13/87	Routine	6 00	195	12 0	246	0187 881 096	0187 881 096	0187 881 095	0187 881 098

Table 4
Cont

Groundwater Sample Information

for Regulated Units at Rocky Flats Plant

SAMPLE INFORMATION				FIELD PARAMETERS				LABORATORY BATCH NUMBERS			
WELL NUMBER	NUMBER	DATE	TYPE	pH	CONDUCT (umho/cm)	TEMP (deg C)	SPEC COND (umho/cm)	VOLATILE ORGANICS	METALS	INORGANICS	RADIOCHEMISTRY
West Spray Field Alluvial Wells											
4786	47 86 06 22 87	06/22/87	Routine	7 40	164	11 9	207	0287 881 060	0287 881 060	0287 881 063	0287 881 060
4786	47 86 08 14 87	08/14/87	Routine	7 30	159	13 1	197	0387 881 081	0387 881 091	0387 881 089	0387 881 067
4786	47 86 10 05 87	10/05/87	Field Split					8710 017 0020	No Sample	No Sample	No Sample
4786	47 86 10 05 87	10/05/87	Routine	6 50	163	15 1	195	0487 881 010	0487 881 011	0487 881 010	0487 881 007
4786	47 86 02 08 88	02/08/88	Routine	6 10	179	7 2	243	0188 881 108	0188 881 108	0188 881 108	0188 881 108
4986	6498611860	11/24/86	Routine	6 10	295	11 5	378	8612 002 021	8612 002 022	8612 002 023	1000 000 293
4986	49 86 04 08 87	04/08/87	Routine	7 00	400	11 0	512	0187 881 041	0187 881 041	0187 881 043	0187 881 043
4986	49 86 06 18 87	06/18/87	Routine	6 20	330	11 7	418	0287 881 053	0287 881 053	0287 881 057	0287 881 053
4986	49 86-08 25 87	08/25/87	Routine	7 40	280	12 5	350	0387 881 096	0387 881 106	0387 881 102	0387 881 085
4986	49 86 12 14 87	12/14/87	Routine	7 20	188	8 8	249	0487 881 065	0487 881 062	0487 881 048	0487 881 016
5086	6508610860	10/31/86	Routine	6 80	245	11 0	314	8611 004 021	8611 004 022	8611 004 023	1000 000 294
5086	6508610862	10/31/86	Field Duplicate	6 90	230	11 5	292	8611 004 016	8611 004 017	8611 004 018	1000 000 295
5086	50 86 05-11 87	05/11/87	Routine	7 00	280			0187-881 081	0187 881 081	0187 881 084	0187 881 084
5086	50 86 06 16 87	06/16/87	Routine	7 50	166	13 6	204	0287 881 049	0287 881 049	0287 881 051	0287 881 049
5086	50 86 08 14 87	08/14/87	Routine	6 50	217	14 5	263	0387 881 085	0387 881 092	0387 881 090	0387 881 068
5086	50 86 12 10 87	12/10/87	Routine	7 00	261	11 5	331	0487 881 055	0487 881 047	0487 881 042	0487 881 014
5186	6518611860	11/07/86	Routine					8611 014 016	8611 014 017	8611 014 018	1000 000 296
5186	51 86 05 13 87	05/13/87	Routine					0187 881 093	0187 881 093	0187 881 097	0187 881 099
5186	51 86 06 17 87	06/17/87	Routine	7 20	178	13 2	220	0287 881 058	0287 881 058	0287 881 052	0287 881 058
5186	51 86 08 20 87	08/20/87	Routine	7 40	215	15 5	256	0387 881 090	0387 881 098	0387 881 095	0387 881 074
5186	51 86 12 10 87	12/10/87	Routine	7 10	170	11 5	216	0487 881 058	0487 881 048	0487 881 043	0487 881 015
5186	51 86 02 08 88	02/08/88	Routine	8 40	181	10 6	233	0188 881 105	0188 881 105	0188 881 105	0188 881 105
5686	6568610860	10/02/86	Routine	7 30	300	18 0	342	8610 011 006	8610 011 007	8610 011 008	1000 000 300
5686	56 86 05 19 87	05/19/87	Routine	6 70	295	13 9	360	0187 881 108	0187 881 108	0187 881 110	0187 881 112
5686	56 86 05 27 87	05/27/87	Routine	6 60	318	13 6	391	0287 881 013	0287 881 013	0287 881 013	0287 881 013
5686	56 86 07 15 87	07/15/87	Routine	6 60	295	19 9	325	0387 881 035	0387 881 145	0387 881 043	0387 881 016
5686	56 86 09 30 87	09/30/87	Field Split					8710 006 0080	No Sample	No Sample	No Sample
5686	56 86 09 30 87	09/30/87	Routine	6 30	276	19 3	307	0487 881 004	0487 881 004	0487 881 004	0487 881 003
5686	56 86 10 01 87	10/01/87	Field Split					No Sample	No Sample	No Sample	0187 123 010
5686	56 86 02 15 88	02/15/88	Routine	7 40	313	6 1	431	0188 881 136	0188 881 136	0188 881 136	0188 881 136
West Spray Field Bedrock Wells											
4686	6468611860	11/13/86	Routine	9 80	320	11 0	410	8611 027 016	8611 027 017	Insufficient Sample	Insufficient Sample
4686	46 86 05 14 87	05/14/87	Routine	5 50	424	14 5	513	0187 881 101	0187 881 101	0187 881 104	0187 881 106
4686	46 86 06 22 87	06/22/87	Routine	7 90	370	12 3	464	0287 881 059	0287 881 059	0287 881 062	0287 881 059
4686	46 86 08 14 87	08/14/87	Routine	8 00	357	13 2	441	0387 881 080	0387 881 090	0387 881 088	0387 881 066
4686	46 86 10 05 87	10/05/87	Field Split					8710 017 0010	No Sample	No Sample	No Sample
4686	46 86 10 05 87	10/05/87	Routine	7 00	403	13 4	496	0487 881 009	0487 881 010	0487 881 009	0487 881 006
4686	46 86-10 06 87	10/06/87	Field Split					No Sample	No Sample	No Sample	0187 123 017
4686	46 86 02 12 88	02/12/88	Routine	7 60	403	12 2	506	0188 881 112	0188 881 112	0188 881 112	0188 881 112
4886	48 86 04 08 87	04/08/87	Routine					0187 881 039	0187 881 039	0187 881 042	0187 881 042
4886	48 86 06 18 87	06/18/87	Routine	9 60	238	13 4	2?3	0287 881 054	0287 881 054	0287 881 058	0287 881 054

Tal
Cont

Groundwater Sample Information

for Regulated Units at Rocky Flats Plant

WELL NUMBER	SAMPLE INFORMATION NUMBER	DATE	TYPE	FIELD PARAMETERS pH	CONDUCT (umho/cm)	TEMP (deg C)	SPEC COND (umho/cm)	VOLATILE ORGANICS	LABORATORY BATCH NUMBERS METALS	INORGANICS	RADIOCHEMISTRY
West Spray Field Bedrock Wells											
4086	40 86 08 25 87	08/25/87	Routine	8 60	351	12 7	437	0387 001 095	0387 001 105	0387 001 101	0387 001 084
4086	40 86 12 14 87	12/14/87	Routine	9 30	198	9 0	261	0487 001 064	0487 001 052	0487 001 047	0487 001 052
5286	52 86 10 02 86	10/02/86	Field Split					0710 006 0030	No Sample	No Sample	No Sample
5286	52 86 05 13 87	05/13/87	Routine	7 00	244	13 4	301	0187 001 125	Insufficient Sample	0187 001 098	0187 001 100
5286	52 86 06 18 87	06/18/87	Routine	10 60	224	13 1	277	0287 001 084	0287 001 084	0287 001 056	0287 001 079
5286	52 86 08 19 87	08/19/87	Routine	8 80	246	15 4	293	0387 001 089	0387 001 095	0387 001 093	0387 001 072
5286	52 86 10 02 87	10/02/87	Field Split					No Sample	No Sample	No Sample	0187 123 068
5286	52 860 10 02 87	10/02/87	Field Duplicate					0487 001 006	0487 001 007	0487 001 006	0187 123 009
5286	52 86-10 02 87	10/02/87	Routine	9 40	187	13 6	230	0487 001 005	0487 001 006	0487 001 005	0487 001 004
5286	52 86 02 08 88	02/08/88	Routine	8 70	200	10 0	260	0188 001 104	0188 001 104	0188 001 104	0188 001 104

Analytical results from well 55-86 have been examined for consistency over time If a result is inconsistent in magnitude with other results from the well, it is excluded as an outlier from consideration in developing the background range The outlier values may be due to laboratory error in analysis, a data reporting error, or field contamination of the sample, however, they could also be natural concentration variations for the analyte The exclusion of high-valued outliers from the background characterization results in a conservative comparison between background and downgradient conditions

Table 5-2 provides the analyte concentration ranges for background alluvial ground water Alluvial ground water west of the Plant is of excellent quality, characterized by low concentrations of major ions, metals, and radionuclides Organic compounds are not above detection limits and pH ranges from 5 60 to 9 00 Background alluvial ground-water chemistry will be reevaluated by additional well installation and ground-water sampling during 1988 field investigations

It should be noted that background ground-water quality was previously established and described in the 881 Hillside Remedial Investigation Report, March 1988 (Rockwell International, 1988) Data for some analytes for West Spray Field alluvial wells 10-81, 49-86, 50-86, 56-86, 47-86, and 51-86 were evaluated and used, if appropriate, to increase the size of the background data base Although a logical rationale was provided on the use of these data, in order to simplify presentation of ground-water quality impacts at the West Spray Field these data are not considered a priori estimates of background alluvial ground-water quality However, as in the 881 Hillside Remedial Investigation Report, it is concluded there are no impacts to ground-water quality with respect to these analytes

METALS

Metal concentrations are generally low in the alluvial ground water at well 55-86 Of the twenty-three metals for which analyses were conducted, fourteen were either not detected or detected at estimated values below the detection limits The non-detected metals, together with the detection limits, are

1 Antimony (0 02 mg/l)
2 Arsenic (0 005 mg/l)
3 Cadmium (0 005 mg/l)
4 Cesium (0 02 mg/l)
5 Chromium (0 01 mg/l)
6 Cobalt (0 022 mg/l)
7 Lithium (0 1 mg/l)
8 Mercury (0 0002 mg/l)
9 Molybdenum (0 022 mg/l)
10 Nickel (0 037 mg/l)
11 Selenium (0 005 mg/l)
12 Silver (0 0076 mg/l)
13 Thallium (0 01 mg/l)
14 Vanadium (0 024 mg/l)

For these metals, the detection limits are considered the maximum reasonable values for background conditions

The other nine metals were detected in enough samples that a background range can be established, as follows

1 Aluminum concentrations varied from below the CLP detection limit of 0 029 mg/l to a maximum concentration of 0 740 mg/l Dixon's Test indicates 0 740 mg/l is an outlier and therefore the background range for aluminum is less than 0 029 mg/l to 0 22 mg/l

2 Barium was detected in the range of 0 048 to 0 140 mg/l Dixon's Test indicates the value 0 140 to be an outlier, therefore, the background range is 0 048 mg/l to 0 071 mg/l

3 Beryllium (0 005 mg/l) was present above detection limits only once in all the samples collected from well 55-86 The concentration detected was 0 011 mg/l and is close enough to the detection limit to be the upper bound of the background range

4 Copper concentrations were less than the detection limit of 0 0063 mg/l in all samples except one, in which the concentration was 0 046 mg/l (the duplicate sample was 0 012 mg/l) Because the lower of the detected values is near the detection limit, this value is included in the background range of less than 0 0063 to 0 012 mg/l

5 Iron concentrations were usually greater than the detection limit of 0 0069 mg/l and were as high as 0 54 mg/l Dixon's Test indicates the value 0 54 to be an outlier, therefore, the background range is established as less than 0 0069 mg/l to 0 125 mg/l

6 Lead was generally not detected above the detection limit of 0 005 mg/l, however, there are two values (0 010 and 0 016 mg/l) that are observed above the detection limit Dixon's Test indicates the value 0 016 mg/l to be an outlier, therefore, the background range is established as less than 0 005 mg/l to 0 01 mg/l

7 Manganese concentrations were usually greater than the detection limit of 0 005 mg/l, generally in the range of 0 0068 to 0 066 mg/l There was one value of 0 55 mg/l that is an outlier by Dixon's Test So, the range of less than 0 005 to 0 066 mg/l is considered reasonable for background conditions

8 Strontium concentrations were uniformly detected in the range of 0 11 to 0 16 mg/l, and this is considered reasonable for background conditions

9 Zinc concentrations were uniformly detected in the range of less than 0 02 to 0 086 mg/l This is considered the background range for zinc

RADIONUCLIDES

Background alluvial ground water contains low concentrations of radionuclides Plutonium, americium, and uranium-235 concentrations generally have uncertainties associated with the determination that are on the order of the determination itself Uncertainty arises in radiometrically determined concentrations because radioactive decay (the measured parameter) is a random process The reported value is an estimate of the mean value that could be developed from the range of values obtained from repeated measurements on the same sample The uncertainties reported in this work are equivalent to two standard deviations about the estimate of the mean (i e, the true value is in a band defined by the estimated mean plus or minus the uncertainty, to a confidence of approximately 95 percent) Radiometrically determined concentrations with uncertainties equal to or greater than the estimate of the mean are similar to non-detectable concentrations of non-radioactive parameters because the concentration is not really quantifiable at the reported mean level However, the determination differs from the more standard result in that the determination allows the analyst to establish confidence limits about the true mean, i e, the true mean is somewhere between the reported mean less the uncertainty (zero in the situation under discussion) and the reported mean plus the uncertainty Therefore, although the determined concentrations of plutonium, americium, and uranium-235 appear to approach 0 pCi/l, additional determinations can be expected to fall in the range between zero and the average of the background uncertainties, about 0 4 pCi/l for plutonium, about 0 9 pCi/l for americium, and about 0 3 pCi/l for uranium-235, based on data in Appendix D

Uranium-234 and uranium-238 were determined at concentrations exceeding the associated uncertainties The October 1986 radiometric results are higher and have smaller uncertainties than data from the four quarters of 1987 and the first quarter of 1988 Dixon's Test indicates these values of 5 4(0 5) pCi/l and 6 7(0 6) pCi/l for uranium-234 and -238, respectively, are outliers Therefore, the background range for uranium-234 is less than the minimum detectable activity (MDA) to 1 5(0 9) pCi/l, and for uranium-238 the range is less than the MDA to 2 2(0 8) pCi/l

MAJOR IONS

Total dissolved solids (TDS) are generally low in alluvial well 55-86, with concentrations ranging from 134 to 167 mg/l Concentrations of specific cations and anions that make up the majority of the TDS are as follows

Major Cations

1 Calcium concentrations were of consistent magnitude in all samples analyzed, ranging from 22 to 34 mg/l

2 Magnesium concentrations were also of consistent magnitude, in the range of 3 6 to 5 9 mg/l

3 Potassium concentrations for alluvial well 55-86 were generally in the range of 0 7 to 0 8 mg/l in all samples except one, in which the concentration was 4 7 mg/l (1986 initial Phase 2) Dixon's Test indicates this value to be an outlier Therefore, the background range is established as 0 7 to 0 8 mg/l

4 Sodium concentrations were of consistent magnitude in all samples analyzed, ranging from 8 to 13 mg/l

Major Anions

1 Bicarbonate and carbonate ranged from non-detectable to 80 mg/l and 76 mg/l for bicarbonate and carbonate, respectively Given natural ground-water pH ranges, any carbonate anion concentration is considered abnormal Therefore, appropriate background concentrations are considered to be non-detectable to 80 mg/l and non-detectable for bicarbonate and carbonate, respectively

Carbonate becomes the dominant species when pH is greater than 10 3 and bicarbonate is the most abundant species in pH ranges between 6 4 and 10 3, which is also the pH range of natural ground water In the analytical samples, where carbonate is observed to be the dominant species, bicarbonate quantities are generally either very low or non-detectable Therefore, these values are considered outliers

2 Chloride concentrations ranged from 6 to 19 mg/l in all samples taken from alluvial well 55-86

3 Nitrate concentrations were consistent in magnitude in all samples analyzed, ranging from 0 8 to 1 5 mg/l

4 Sulfate concentrations were consistent in magnitude ranging from 15 to 27 mg/l

Overview of Alluvial Ground-water Quality

This evaluation is based on West Spray Field alluvial ground-water data collected since 1986 The 1986 wells have six quarters of analytical results (the last quarter of 1986, four quarters of 1987, and the first quarter of 1988) Tables 5-5, 5-6, and 5-7 compare West Spray Field ground-water analytical data to background concentrations

Twelve alluvial wells have been installed in the vicinity of the West Spray Field to monitor ground-water quality The alluvial ground-water system in the West Spray Field can be divided into five subareas The first area consists of the ground water in the upgradient wells 10-81, 7-82, and 51-86 However, well 7-82 was dry during the sampling efforts, therefore no analytical data are available for this alluvial well The second area, within the West Spray Field itself, includes wells 5-82, 6-82, 49-86, and 50-86 Alluvial well 47-86 to the north of the West Spray Field represents the third area The fourth area of wells is located downgradient adjacent to North Walnut Creek and includes wells 8-81, 9-81, and 45-86 The fifth area is located southeast and potentially downgradient of the West Spray Field along Woman Creek at well 56-86

Analytical results revealed that semi-volatile and volatile organic compounds (VOCs) were rarely detected above background Methylene chloride, acetone, 2-butanone and carbon tetrachloride were sporadically observed only slightly above detection limits at the West Spray Field These VOCs are common laboratory reagents and their presence is not considered indicative of impacted West Spray Field alluvial ground water

TABLE 5-5
METALS CONCENTRATIONS ABOVE BACKGROUND IN ALLUVIAL WELLS (mg/l)

Well Number Background	Date Sampled ------------	Al (0 22)	Ba (0 071)	Be (0 011)	Cd (0 005U)	Cs (0 02U)	Cr (0 01U)	Co (0 022U)	Cu (0 012)	Fe (0 125)	Pb (0 010)
10-81	08/08/86	0 680	-	0 037	-	0 360	-	0 10	-	0 270	-
	05/11/87	-	0 135	-	-	-	-	-	-	-	-
	06/18/87	-	-	-	-	-	-	-	-	-	-
	08/21/87	-	0.101	-	-	-	0 0144	-	-	-	-
	08/21/87(Dup)	-	0.102	-	-	-	-	-	-	-	-
	01/12/88	-	-	-	0 018	-	-	-	-	-	-
	02/04/88	-	0 087	-	-	-	-	-	-	-	-
51-86	11/07/86	-	0.110	-	0.006	-	0 027	-	0 023	-	-
	05/13/87	-	0 133	-	-	-	-	-	-	-	-
	06/19/87	-	-	-	-	-	-	-	-	-	0 036
	08/20/87	0 83	0 150	-	-	-	0 0173	-	-	0 5748	-
	12/10/87	-	0 074	-	-	-	0 0152	-	0 014	-	-
	02/08/88	-	0.099	-	-	-	-	-	-	-	-
05-82	08/13/86	-	0 150	-	-	-	-	-	-	-	-
	05/13/87	0 23	0 090	-	-	-	-	-	-	0 1632	-
	06/18/87	-	-	-	-	-	-	-	-	-	0 014
	09/17/87	0 28	0 106	-	0 002	-	-	-	-	0 2598	-
	01/07/88	-	0 077	-	-	-	-	-	-	-	-
06-82	08/18/86	-	0 290	0 040	-	-	0 022	-	-	0 180	0 016
	05/12/87	1 86	0.223	-	-	-	-	-	-	1 2989	-
	06/18/87	-	-	-	-	-	-	-	-	-	0 021
	08/18/87	-	0 127	-	-	-	-	-	-	0 1506	-
	01/07/88	-	0.076	-	0 006	-	0 0124	-	0 014	-	-
49-86	11/24/86	-	0 116	-	-	-	-	-	-	-	-
	01/08/87	-	0 516	-	-	-	-	-	-	-	-
	06/18/87	-	-	-	-	-	-	-	-	-	0 020
	08/'5/87	-	0.120	-	-	-	-	-	-	-	-
	1[illegible]/14/87	-	0 105	-	-	-	-	-	-	-	-
50-86	10/31/86	-	0 080	-	-	-	-	-	-	0 076	0 016
	10/31/86(Dup)	-	0 190	-	-	-	-	-	-	0 181	0 054
	05/11/87	-	0 1558	-	-	-	0 1356	-	0 026	0 5953	-
	06/16/87	-	-	-	-	-	-	-	-	-	0 015
	08/14/87	-	0 082	-	-	-	0 0114	-	-	-	-
	12/10/87	0 59	0 1607	-	-	-	0 0148	-	0 038	0 4740	-

TABLE 5-5 (Continued)
METALS CONCENTRATIONS ABOVE BACKGROUND IN ALLUVIAL WELLS (mg/l)

Well Number Background	Date Sampled	Al (0.22)	Ba (0.071)	Be (0.011)	Cd (0 005U)	Cs (0 02U)	Cr (0 01U)	Co (0 022U)	Cu (0 012)	Fe (0 125)	Pb (0.010)
47-86	11/07/86	-	0 100	-	0 007	-	0 010U	-	-	-	-
	11/07/86(Dup)	-	0 100	-	0 008	-	0 027	-	-	-	-
	05/13/87	-	-	-	-	-	-	-	-	-	-
	06/22/87	-	-	-	-	-	-	-	-	-	0 036
	08/14/87	-	0 102	-	-	-	-	-	-	-	-
	10/05/87	-	-	-	-	-	-	-	-	-	-
	10/05/87(Dup)	-	-	-	-	-	-	-	-	-	-
	02/08/88	-	-	-	-	-	-	-	-	-	-
08-81	08/18/86	-	-	-	-	-	-	-	0 030	-	-
	05/14/87	-	0 123	-	-	-	-	-	-	-	-
	06/23/87	-	0 076	-	-	-	-	-	-	-	0 019
	08/18/87	-	0 114	0 080	-	-	0 013	-	-	-	-
	01/14/88	-	0 098	-	0 008	-	-	-	0 019	-	-
	01/14/88(Dup)	-	-	-	-	-	-	-	-	-	-
09-81	08/14/86	-	-	-	-	-	-	-	-	-	-
	05/19/87	-	-	-	-	-	-	-	-	-	-
	06/23/87	-	-	-	-	-	-	-	-	-	0 018
	08/18/87	-	-	-	-	-	-	-	-	-	-
	01/13/88	-	-	-	-	-	-	-	-	-	-
45-86	10/16/86	0 48	0 150	0.007	-	-	-	-	-	0 242	-
	10/16/86(Dup)	0 55	0 160	0.011	-	-	-	-	-	0 252	-
	05/14/87	-	-	-	-	-	-	-	-	-	-
	06/12/87	-	-	-	-	-	-	-	-	-	-
	08/14/87	-	-	-	-	-	0 0115	-	-	-	-
	09/30/87	-	-	-	-	-	-	-	-	-	-
	10/01/87	-	-	-	-	-	-	-	-	-	-
56-86	10/02/86	-	-	-	-	-	-	-	-	-	-
	05/19/87	-	-	-	-	-	0 0257	-	-	0 3115	-
	05/27/87	0 33	-	-	-	-	-	-	-	0 3674	0 018
	07/15/87	-	0 085	-	-	-	-	-	-	-	-
	09/30/87	-	0 103	-	-	-	-	-	-	-	-
	10/01/87	-	-	-	-	-	-	-	-	-	-
	02/15/88	-	0 122	-	-	-	-	-	-	-	-

TABLE 5-5 (Continued)
METALS CONCENTRATIONS ABOVE BACKGROUND IN ALLUVIAL WELLS (mg/l)

Well Number	Date Sampled	Mn	Hg	Mo	Ni	Se	Sr	Tl	V	Zn
Background	-----------	(0.066)	(0.0002U)	(0 022U)	(0.037U)	(0 005U)	(0.16)	(0 01U)	(0 024U)	0 086)
10-81	08/08/86	-	0 0007	0 510	0 077	-	-	-	0 850	-
	05/11/87	-	-	-	-	-	-	-	-	-
	06/18/87	-	-	-	-	-	-	-	0 0245	-
	08/21/87	-	-	-	-	-	-	-	-	0 1858
	08/21/87(Dup)	-	-	-	-	-	-	-	-	-
	01/12/88	-	-	-	-	-	-	-	-	-
	02/04/88	-	-	-	-	-	-	-	-	-
51-86	11/07/86	0 071	-	-	-	-	-	-	-	-
	05/13/87	-	-	-	-	-	-	-	-	-
	06/19/87	-	-	-	-	-	-	-	-	-
	08/20/87	-	-	-	-	-	-	-	-	-
	12/10/87	-	-	-	-	-	-	-	-	-
	02/08/88	-	-	-	-	-	-	-	-	0 1683
05-82	08/13/86	-	0 0012	-	-	-	0 180	0 014	-	1 580
	05/13/87	-	-	-	-	-	-	-	-	-
	06/18/87	-	0 0003	-	0 0431	-	-	-	-	-
	09/17/87	-	-	-	-	-	0 1891	-	-	0 1695
	01/07/88	-	-	-	-	-	0 1720	-	-	1 7771
06-82	08/18/86	0 140	-	-	0 060	-	-	-	-	0 102
	05/12/87	0 1355	-	-	-	-	-	-	-	-
	06/18/87	0 2864	-	-	0 0485	-	-	-	-	-
	08/18/87	-	-	-	-	-	-	-	-	-
	01/07/88	-	-	-	-	-	-	-	-	0 1000
49-86	11/24/86	0 476	-	-	-	-	0 205	-	-	-
	04/08/87	0 2289	-	-	-	-	0 1843	-	-	0 49
	06/18/87	-	-	-	-	-	-	-	-	-
	08/25/87	-	-	-	-	-	-	-	-	-
	12/14/87	-	-	-	-	-	-	-	-	-
50-86	10/31/86	0 347	-	-	-	-	0 150	-	-	-
	10/31/86(Dup)	0 374	-	-	-	-	0 164	-	-	-
	05/11/87	0 1940	-	-	0 0701	-	0 1750	-	-	-
	06/16/87	-	-	-	-	-	0 1768	-	-	-
	08/14/87	-	-	-	-	-	0 1791	-	-	-
	12/10/87	-	-	-	-	-	0 1834	-	-	-

TABLE 5-5 (Continued)
METALS CONCENTRATIONS ABOVE BACKGROUND IN ALLUVIAL WELLS (mg/l)

Well Number	Date Sampled	Mn	Hg	Mo	Ni	Se	Sr	Tl	V	Zn
Background	-----------	(0 066)	(0 0002U)	(0 022U)	(0.037U)	(0 005U)	(0 16)	(0 01U)	(0 024U)	0 086)
47-86	11/07/86	0 086	-	-	-	-	-	-	-	-
	11/07/86(Dup)	0.093	-	-	-	-	-	-	-	-
	05/13/87	-	-	-	-	-	-	-	-	-
	06/22/87	-	0 003	-	-	-	-	-	0 0275	-
	08/14/87	-	-	-	-	-	-	-	-	-
	10/05/87	-	-	-	-	-	-	-	-	-
	10/05/87(Dup)	-	-	-	-	-	-	-	-	-
	02/08/88	-	-	-	-	-	-	-	-	0 1072
08-81	08/18/86	-	-	-	-	-	0 2981	-	-	-
	05/14/87	-	-	-	-	-	0 2554	-	-	-
	06/23/87	-	-	-	-	-	0 2935	-	0 0398	-
	08/18/87	-	-	-	-	0 0082	0 250	-	-	-
	01/14/88	-	-	-	-	-	0 2996	-	-	-
	01/14/88(Dup)	-	-	-	-	-	-	-	-	-
09-81	08/14/86	-	0 00022	-	-	-	0 350	0 019	-	0 090
	05/19/87	-	-	-	-	-	0 4268	-	-	-
	06/23/87	-	-	-	-	-	0 4635	-	0 0302	-
	08/18/87	-	-	-	-	-	0 4518	-	-	-
	01/13/88	-	-	-	-	-	0 4188	-	-	-
45-86	10/16/86	0 079	0 0016	-	-	-	0 190	-	-	-
	10/16/86(Dup)	0 091	0 00021	-	-	-	0 193	-	-	-
	05/14/87	-	-	-	-	-	-	-	-	-
	06/12/87	-	-	-	-	-	-	-	-	-
	08/14/87	-	-	-	-	-	-	-	-	-
	09/30/87	-	-	-	-	-	-	-	0 0334	-
	10/01/87	-	-	-	-	-	-	-	-	-
56-86	10/02/86	0.340	-	-	-	-	-	-	-	-
	05/19/87	-	-	-	-	-	0 1668	-	-	-
	05/27/87	-	-	-	-	-	-	-	-	-
	07/15/87	-	-	-	-	-	0 1740	-	0 0323	-
	09/30/87	-	-	-	-	-	0 1674	-	-	-
	10/01/87	-	-	-	-	-	-	-	-	-
	02/15/88	-	-	-	-	-	0 1697	-	-	-

TABLE 5-6
RADIONUCLIDE CONCENTRATIONS ABOVE BACKGROUND IN ALLUVIAL WELLS (pCi/l)

Well Number Background	Date Sampled ------------	Gross Alpha 262(34)	Gross Beta 135(26)	U 233,234 1 5(0 9)	U 235 MDA	U 238 2 2(0 8)	Sr 89,90 3 32	Pu 239,240 MDA	Am 241 MDA	H 3 593
10-81	08/08/86	-	-	-	-	-	-	-	-	-
	05/11/87	-	-	-	-	-	-	-	-	-
	06/18/87	-	-	-	-	-	-	-	-	-
	08/21/87	-	-	-	3 2(1 9)	-	-	-	-	-
	08/21/87(Dup)	-	-	-	-	-	-	-	-	-
	01/12/88	-	-	-	-	-	-	-	-	-
	02/04/88	-	-	-	-	-	-	-	-	-
51-86	11/07/86	-	-	-	-	-	-	-	-	-
	05/13/87	-	-	-	-	-	-	-	-	-
	06/19/87	-	-	-	-	-	-	-	-	-
	08/20/87	-	-	-	-	-	-	-	-	-
	12/10/87	-	-	-	-	-	-	-	-	-
	02/08/88	-	-	-	-	-	-	-	-	-
05-82	08/13/86	-	-	-	-	-	-	-	-	
	05/13/87	-	-	-	-	-	-	-	-	-
	06/18/87	-	-	-	-	-	-	-	-	-
	09/17/87	-	-	-	-	-	-	-	-	1005(316)
	01/07/88	-	-	-	-	-	-	-	-	-
06-82	08/18/86	-	-	-	-	3 7(0 6)	-	-	-	-
	05/12/87	-	-	4 6(1 2)	-	9 7(1 7)	4 69	-	-	-
	06/18/87	311(115)	336(69)	8 9(1 4)	-	7 4(1 2)	-	-	-	-
	08/18/87	-	-	-	-	-	-	-	-	-
	01/07/88	-	-	-	-	-	-	-	-	-
49-86	11/24/86	350(60)	1200(100)	12(2)	-	12(2)	-	-	-	-
	04/08/87	-	-	-	-	-	-	-	-	-
	06/18/87	-	-	3.5(0.9)	-	4 0(0 9)	-	-	-	-
	08/25/87	-	-	-	-	-	-	-	-	2218(397)
	12/14/87	620(110)	440(30)	-	-	-	-	-	-	-
50-86	10/31/86	-	-	9 0(1 0)	-	6 3(8)	-	-	-	-
	10/31/86(Dup)	-	-	7 9(1 0)	-	5 2(0 9)	-	-	-	-
	05/11/87	-	-	2 5(1 2)	-	-		-	-	-
	06/16/87	-	-	-	-	-	-	-	-	-
	08/14/87	-	-	-	-	-	3 5	-	-	-
	12/10/87	-	-	-	-	-	-	-	-	-

TABLE 5-6 (Continued)
RADIONUCLIDE CONCENTRATIONS ABOVE BACKGROUND IN ALLUVIAL WELLS (pCi/l)

Well Number Background	Date Sampled ------------	Gross Alpha 262(34)	Gross Beta 135(26)	U 233,234 1 5(0 9)	U 235 MDA	U 238 2 2(0 8)	Sr 89,90 3 32	Pu 239,240 MDA	Am 241 MDA	H 3 593
47-86	11/07/86	-	-	10(2)	-	14(2)	-	-	-	-
	11/07/86(Dup)	-	-	6 0(1 1)	-	7 7(1 2)	-	-	-	-
	05/13/87	-	-	-	-	-	-	-	-	-
	06/22/87	-	-	-	-	-	-	-	-	-
	08/14/87	-	-	-	4(1 4)	5 5(2 1)	-	-	-	-
	10/05/87	-	-	-	-	-	-	-	-	-
	10/05/87(Dup)	-	-	-	-	-	-	-	-	-
	02/08/88	-	-	-	-	-	-	-	-	-
08-81	08/18/86	-	-	3.2(0 4)	-	-	-	0 16(0 10)	-	-
	05/14/87	-	-	3 7(1 0)	-	-	-	-	-	-
	06/23/87	295(32)	238(43)	3 2(1 0)	-	4 5(1 0)	-	-	-	-
	08/18/87	-	-	4.4(1.6)	-	4 6(1 4)	-	-	-	-
	01/14/88	-	-	3.6(0 5)	-	-	-	-	-	-
	01/14/88(Dup)	-	-	-	-	-	-	-	-	-
09/81	08/14/86	-	-	-	-	-	-	-	-	-
	05/19/87	-	-	-	-	-	-	-	-	-
	06/23/87	-	-	-	-	-	-	-	-	-
	08/18/87	-	-	-	-	-	-	-	-	-
	01/13/88	-	-	-	-	-	-	-	-	-
45-86	10/16/86	-	140(30)	11(1)	-	10(1)	-	-	-	-
	10/16/86(Dup)	-	250(40)	15(2)	-	16(2)	-	-	-	-
	05/14/87	-	-	-	-	-	-	4 7(1 8)	-	-
	06/12/87	-	-	-	-	-	-	-	-	-
	08/14/87	-	-	-	-	9 8(2 3)	-	0 106(0 062)	-	-
	09/30/87	-	-	-	-	-	-	-	-	-
	10/01/87	-	-	-	-	-	-	-	-	-
56-86	10/02/86	-	-	-	-	-	-	0 09(0 06)	-	-
	05/19/87	-	-	-	-	-	4 01	-	-	-
	05/27/87	-	-	-	-	-	-	-	-	-
	07/15/87	-	-	-	0 5(0 3)	-	-	-	-	-
	09/30/87	-	-	-	-	-	-	-	-	-
	10/01/87	-	-	-	-	-	-	-	-	-
	02/15/88	-	-	-	-	-	-	-	-	-

TABLE 5-7
MAJOR ION CONCENTRATIONS ABOVE BACKGROUND IN ALLUVIAL WELLS (mg/l)

Well Number	Date Sampled	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	HCO_3^{-}	$CO_3^{=*}$	Cl^{-}	NO_3^{-}	$SO_4^{=}$	TDS
Background	---------------	34	5 9	0 8	13	80	5U	19	1 5	27	167
10-81	08/08/86	-	6 6	-	-	-	21(19)	-	-	-	-
	05/11/87	-	-	-	-	-	-	-	2 00	-	-
	06/18/87	-	-	-	-	-	-	444	7 30	-	-
	08/21/87	-	-	-	13 9764	-	-	-	7 65	-	-
	08/21/87(Dup)	-	-	-	14 4885	-	-	-	7 85	-	-
	01/12/88	-	-	-	-	-	-	-	6 10	-	-
	02/04/88	-	-	-	13 0288	-	-	-	5 98	-	-
51-86	11/07/86	-	-	1 07	-	-	42(3U)	-	-	31 0	277
	05/13/87	-	-	-	14 6574	-	-	-	4 65	31 0	-
	06/19/87	-	-	-	-	-	-	-	4 60	28 0	-
	08/20/87	-	-	-	16 3487	-	-	-	5 15	-	-
	12/10/87	-	-	-	-	-	-	-	3 45	190	-
	02/08/88	-	-	-	-	-	-	-	4 91	56 0	-
05-82	08/13/86	36 2	-	15 5	23 3	-	-	55	32 4	77	245
	05/13/87	-	-	-	18 5408	-	-	-	1 88	60 0	186
	06/18/87	-	-	-	20 5830	-	-	32 3	2 60	49 0	228
	09/17/87	-	-	0.95	25 5351	-	-	53 4	3 8	62	210
	01/07/88	-	-	-	23 6020	-	-	43 1	3 38	653	232
06-82	08/18/86	-	-	-	-	-	-	-	-	-	-
	05/12/87	-	-	-	-	-	-	-	-	80 0	365
	06/18/87	-	-	-	-	-	-	-	-	37 5	-
	08/18/87	-	-	-	-	-	-	-	-	28 5	500
	01/07/88	-	-	1 3	-	-	-	-	-	90 2	192
49-86	11/24/86	35 20	7 640	-	29 500	-	45(7)	30	-	29	477
	04/08/87	34 77	7.3621	-	36 0378	-	-	20 2	9 10	150	264
	06/18/87	-	-	-	27 8577	-	-	23 7	16 3	30 5	269
	08/25/87	-	-	1 3	26 6908	-	-	30 6	12 6	-	201
	12/14/87	-	-	-	21 2591	-	-	-	6 58	1340	309
50-86	10/31/86	-	-	1 5	-	130	-	-	-	-	200
	10/31/86(Dup)	-	-	2 1	-	-	-	-	-	-	210
	05/11/87	36 45	-	-	-	95 0	-	-	-	28 0	-
	06/16/87	34 42	-	-	-	92 5	-	-	-	-	171
	08/14/87	-	-	-	-	95 7	-	-	-	-	-
	12/10/87	-	-	-	-	119	-	-	-	27 4	-

TABLE 5-7 (Continued)
MAJOR ION CONCENTRATIONS ABOVE BACKGROUND IN ALLUVIAL WELLS (mg/l)

Well Number	Date Sampled	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	HCO_3^{-}	$CO_3^{=}$*	Cl^{-}	NO_3^{-}	$SO_4^{=}$	TDS
Background	--------------	34	5 9	0 8	13	80	5U	19	1 5	27	167
47-86	11/07/86	-	-	1 00U	14 700	-	88(5 4)	-	-	-	264
	11/07/86(Dup)	-	-	1 04	16 400	-	-	-	-	-	290
	05/13/87	-	-	-	15 6347	-	-	-	-	-	-
	06/22/87	-	-	-	13 0281	-	-	-	-	-	-
	08/14/87	-	-	-	17 2126	-	-	-	-	-	-
	10/05/87	-	-	-	13 2303	-	-	-	-	-	-
	10/05/87	-	-	-	-	-	-	-	-	-	-
	02/08/88	-	-	-	13 0176	87 3	-	-	-	-	-
08-81	08/18/86	73.3	-	1 8	13 8	-	-	-	-	-	-
	05/14/87	36 2560	7 9690	-	17 6824	131	-	-	-	-	185
	06/23/87	49 8042	7 0867	-	18 9038	109	7 45(109)	-	-	32 0	213
	08/18/87	45 0880	7 4774	-	20 8643	-	-	-	-	-	-
	01/14/88	36 2776	8 8584	2 3	18 0305	153	-	-	-	-	194
	01/14/88(Dup)	-	-	-	-	-	-	-	-	-	-
09-81	08/14/86	-	-	5 88	15 9	-	85(10U)	49 0	-	55 0	244
	05/19/87	50 6558	-	-	22 5516	102	-	54 6	-	49 5	269
	06/23/87	54 8688	-	-	22 6974	-	-	51 3	-	48 0	277
	08/18/87	49 6003	-	1 4	25 8222	84 4	-	52 6	-	47 0	286
	01/13/88	45 0152	-	1 4	22 8651	100	-	51 6	-	39 9	249
45-86	10/16/86	-	-	-	13 4	-	110(12)	-	-	-	160
	10/16/86(Dup)	-	-	-	13 9	-	5U(4 9)	-	-	-	180
	05/14/87	-	-	-	-	-	-	-	-	-	-
	06/12/87	-	-	-	-	-	-	-	-	-	-
	08/14/87	-	-	-	-	-	-	-	-	-	-
	09/30/87	-	-	-	-	-	-	-	-	-	-
	10/01/87	-	-	-	-	-	-	-	-	-	-
56-86	10/02/86	-	6 210	2 6	17 800	-	120(16)	-	-	-	210
	05/19/87	-	6 8858	-	21 4615	105	-	-	-	-	185
	05/27/87	-	-	-	19 2985	121	-	19 3	-	-	202
	07/15/87	-	6 8215	2 9	21 9101	124	-	-	-	-	186
	09/30/87	-	6 4920	2 4	19 9013	122	-	19 6	-	-	191
	10/01/87	-	-	-	-	-	-	-	-	-	-
	02/15/88	-	6 8235	1 7	24 6484	91 7	-	49 5	1 66	39 5	213

* ( ) HCO_3 Value

Ground-Water Quality of the Upgradient Wells

Alluvial wells 10-81 and 51-86 appear to be upgradient from the West Spray Field based on surface topography and ground-water levels obtained from the limited data points This may not have always been the case Dewatering of the gravel/clay pits just west of the site, increased evaporation from these pits and/or an induced mounding effect from the artificial recharge produced from the West Spray Field may have temporarily changed the hydraulic gradient toward these alluvial wells Also westerly winds may have blown the spray toward the area monitored by wells 10-81 and 51-86

The data from these two wells show slightly increased barium and chromium in several of the samples Above background concentrations were sporadically observed for the other metals except cesium, strontium or thallium These values vary widely over time with no apparent seasonal pattern These occasionally and slightly elevated metal concentrations are assumed to represent natural geochemical variations in the alluvial ground water

Radionuclide concentrations were not above background in the 1986 sampling of well 10-81 Uranium-235 was observed above the MDA (3 2$\pm$1 9 pCi/l) This is the only occurrence of uranium-235 above the MDA in this well and is considered an outlier

Ground water at wells 10-81 and 51-86 appear to have similar inorganic composition Nitrate is notably elevated above background on several sampling dates and likely represents an impact from the West Spray Field operation Sodium and sulfate were also observed above background levels but are generally near background levels

Ground-Water Quality within the West Spray Field

Wells 5-82, 6-82, 49-86 and 50-86 all are within the West Spray Field Barium, iron, manganese, and strontium concentrations were regularly elevated above background but generally within a factor of 2-3 of background levels It is possible these elevated metal concentrations represent an impact from the West Spray Field operation Other metals sporadically occurred above background levels but likely represent natural geochemical variations in ground-water chemistry

Uranium-233 + -234, and -238 showed values elevated above background in wells 06-82, 49-86, and 50-86 The highest concentrations occurred in the 1986 sampling with occasional above background levels in subsequent sampling It should be noted that high uranium concentrations occurred in 1986 in the background well (55-86) but were discounted as outliers in determining the background uranium concentrations The high values in 1986 for wells 49-86 and 50-86 also "fall out" as outliers applying Dixon's Test Only in well 6-82 do historical uranium concentrations appear to be above background and not be outliers However, late 1987 and first quarter 1988 samples do not show elevated uranium concentrations Although elevated uranium occurred in the water sprayed at the West Spray Field, it cannot be conclusively stated that uranium is a contaminant of alluvial ground water in the West Spray field Actinide series metals should be effectively removed by the soil, however, elevated uranium is not notable in the soils of the West Spray Field which implies the quantity of uranium applied is lower than might be expected Lastly, strontium-89 +-90 and plutonium-239+ -240 also showed only one increased value in well 06-82 Tritium appeared only once above background in wells 05-82 and 49-86

The most likely indicator of contamination in the West Spray Field alluvial ground-water quality is nitrate, and to a lesser extent sodium and sulfate On several occasions, nitrate was detected above background at wells 05-82 and 49-86 Sulfate and sodium were also elevated in these wells Wells 06-82 and 50-86 generally showed increased sulfate values, but nitrate and sodium values were below background Bicarbonate values were slightly elevated in well 50-86, but this could easily be related to natural variations of alluvial ground water geochemistry Total dissolved solids (TDS) were observed to be slightly above background in all the West Spray Field wells, which may indicate impacts from the spraying operation

Ground-Water Quality Side-Gradient and North of the West Spray Field

Well 47-86 is the only well currently in this sub-group Metal contamination in this area is not evident There are sporadic values slightly above background for several of the metals, but their low concentration seem to represent only natural alluvial ground water variation Total uranium appears elevated in November, 1986, however, uranium concentrations were at background levels in late 1987 and first quarter 1988

Downgradient Ground-Water Quality Adjacent to North Walnut Creek

Wells 8-81, 9-81, and 45-86 are the wells downgradient of the West Spray Field adjacent to North Walnut Creek Strontium was the only metal that consistently appeared somewhat elevated in wells 08-81 and 09-81 (0 250-0 2996 mg/l and 0 350-0 4635 mg/l, respectively) Strontium was only slightly above background on one occasion in well 45-86 (0 193 mg/l) All other metals showed sporadic concentrations above background and are considered natural alluvial geochemical variation

Above background concentrations of radionuclides appeared only in wells 08-81 and 45-86 In well 8-81, uranium-234 was consistently elevated but generally within a factor of 2-3 of background levels Uranium-238 was elevated above background on two occasions but was also within approximately a factor of 2 of background levels Uranium-238 was above background on two occasions in well 45-86 (10-16 pCi/l and 9 8 pCi/l), as was plutonium-239 +-240 (4 7 and 0 106 pCi/l) Although the plutonium-239+240 value of 4 7 pCi/l is a clear outlier, regardless of whether the other above background radionuclide concentrations represent impacts from the West Spray Field operations, late 1987 data indicate background concentrations of radionuclides

Wells 08-81 and 09-81 showed similar inorganic chemistry with consistently elevated calcium, sodium, and TDS above background Also, bicarbonate was observed above background on several occasions in these wells Magnesium was elevated in well 08-81, while chloride and sulfate were elevated in well 09-81 Major ion chemistry was generally below background in well 45-86

Downgradient Ground-Water Quality along Woman Creek

Well 56-86 is downgradient of the West spray Field and along Woman Creek Barium and strontium appeared slightly elevated on several occasions Other metals occasionally were above background, but this appears to be attributed to natural geochemical variations in ground water There were no consistent detections of radionuclides above background levels The major ions that are consistently elevated in this well are magnesium, sodium, and bicarbonate, TDS is also consistently above the alluvial ground-water background value Chloride values are observed above background on several occasions However, none of these major ions are significantly above background and therefore may represent natural geochemical variations in alluvial ground water

Summary and Conclusions

To facilitate geochemical interpretation of the ground-water data, Table 5-8, Table 5-9, and Table 5-10 were constructed to represent analytes showing greater than three times background values Most of the potential contaminants drop out at this point "Starred" values on this table represent outliers

1 Volatile organic compounds are generally non-detectable in the alluvial ground water near the West Spray Field, except for sporadically elevated concentrations of common laboratory reagents These are not considered to be constituents of the impacted West Spray Field alluvial ground water, because the presence of these substances may be due to laboratory contamination

2 Metal concentrations are generally similar to background conditions except for occasional high concentrations for some metals that do not show any cross correlations with other metals or analytes above background, or any spatial or temporal trends Except for iron and manganese, high concentrations of other metals are either outliers or below the proposed concentration limits Iron and manganese proposed concentration limits are based on aesthetic considerations Therefore, although metal contamination of alluvial ground water is not apparent, even the high metal concentrations observed do not present a health hazard

3 Of the radionuclides, only uranium-233+234 and -238 appear at high concentrations with regularity in the wells of the West Spray Field However, most occurrences are in 1986 which appear to be outliers, and in late 1987 and first quarter 1988 they are at background levels Even if the elevated concentrations represent historic contamination, the concentrations were below the proposed concentration limits

4 Major ion chemistry indicates dominance by sodium, nitrate, and sulfate in alluvial ground water of the West Spray Field (Table 5-7) Sodium is never elevated above three times background (Table 5-10) Sulfate is present above three times background at several locations, but most are considered to be outliers except for well 06-82 on 01/07/88 (90 2 mg/l) Nitrate is the major ion

TABLE 5-8
METAL CONCENTRATIONS ABOVE THREE TIMES BACKGROUND IN ALLUVIAL WELLS (mg/l)

Well Number	Date Background 3x	Ba+ 0.071 0.213	Be 0 011 0.033	Cd 0 005 0 015	Cr 0 01U 0 03	Cu 0 012 0 036	Fe 0 125 0 375	Pb 0 016 0 048	Mn 0 066 0 198	Hg 0 0002U 0 0006	Mo 0 022U 0 066	V 0 024U 0 072	Zn 0 086 0 258
10-81	08/08/86	-	0 037	-	-	-	-	-	-	0 0007	0 510*	0 850*	-
	01/12/88	-	-	0 018*	-	-	-	-	-	-	-	-	-
51-86	08/20/87	-	-	-	-	-	0 5748*	-	-	-	-	-	-
	06/19/87	-	-	-	-	0 036	-	-	-	-	-	-	-
05-82	08/13/86	-	-	-	-	-	-	-	-	0 0012	-	-	1 580
	01/07/88	-	-	-	-	-	-	-	-	-	-	-	1 7771
06-82	08/18/86	-	0.040	-	-	-	-	-	-	-	-	-	-
	05/12/87	-	-	-	-	-	1 2989*	-	-	-	-	-	-
	06/18/87	-	-	-	-	-	-	-	0 2864	-	-	-	-
49-86	04/08/84	0 5163*	-	-	-	-	-	-	0 2289	-	-	-	0 49
50-86	10/31/86	-	-	-	-	-	-	-	0 347	-	-	-	-
	10/31/86(Dup)	-	-	-	-	-	-	0 054	0 374	-	-	-	-
	05/11/87	-	-	-	0 1356*	-	0 5953	-	-	-	-	-	-
	12/10/87	-	-	-	-	0 038	0 4740	-	-	-	-	-	-
47-86	06/22/87	-	-	-	-	-	-	-	-	0 003*	-	-	-
08-81	05/18/87	-	0 080	-	-	-	-	-	-	-	-	-	-
45-86	10/16/86	-	-	-	-	-	-	-	-	0 0016	-	-	-
	10/16/86(Dup)	-	-	-	-	-	-	-	-	-	-	-	-
56-86	10/02/86	-	-	-	-	-	-	-	0 340*	-	-	-	-

* Outlier

TABLE 5-9

RADIONUCLIDE CONCENTRATIONS ABOVE THREE TIMES BACKGROUND IN ALLUVIAL WELLS (pCi/l)

Well Number	Date Sampled		Gross Beta	U^{234}	U^{235}	U^{238}	$Pu^{239,240}$	H^3
		Background	135(26)	(1 5(0 9)	MDA	2 2(8)	MDA	593
		3xBackground	405	4 5		6 6		1779
10-81	08/21/87		-	-	3 2(1 9)*	-	-	-
06-82	05/12/87		-	-	-	-	-	-
	06/18/87		-	8 9(1 4)	-	7 4(1 2)	-	-
49-86	11/24/86		1200(100)	12(2)	-	-	-	-
	08/25/87		-	-	-	-	-	2218(397)
47-86	11/07/86		-	1 (2)	-	14(2)	-	-
	11/07/86 (Dup)		-	6 0(1)	-	7 7(1 2)	-	-
	08/14/87		-		4(1 4)*		-	-
08-81	08/18/86		-	-	-	-	0 16(0 10)	-
45-86	10/16/86		-	11(1)	-	10(1)	-	-
	10/16/86 (Dup)		-	15(2)	-	16(2)	-	-
	05/14/87		-		-		4 7(1 8)*	-
	08/14/87		-	-	-	9 8(2 3)	0 106(0 062)	-
56-86	10/02/86		-	-	-	-	0 09(0 06)	-
	07/15/87		-		0 5(0 3)		-	-
50-86	10/31/86		-	9 0(1 0)	-	-	-	-
	10/31/86 (Dup)		-	7.9(1 0)	-	-	-	-

TABLE 5-10

MAJOR ION CONCENTRATIONS AT THREE TIMES BACKGROUND IN ALLUVIAL WELLS (mg/l)

Well Number	Date Sampled	Major Ion	K^+	CO_3^{--}**	Cl^-	NO_3^-	$SO_4^=$
		Background	0 8	5U	19	1 5	27
		3xBackground	2 4	15	57	4 5	81
10-81	08/08/86		-	21(19)	-	-	-
	06/18/87		-	-	444*	7 30	
	08/21/87		-	-	-	7 65	-
	08/21/87(Dup)		-	-	-	7 85	-
	01/12/88		-	-	-	6 10	-
	02/04/88		-	-	-	5 98	-
51-86	11/07/86		-	42(U)	-	-	-
	05/13/87		-	-	-	4 65	-
	06/17/87		-	-	-	4 60	-
	08/20/87		-	-	-	5 15	-
	12/10/87		-	-	-	-	190*
	02/08/88		-	-	-	4 91	-
05-82	08/13/86		15 5*	-	-	32 4*	-
	01/07/88		-	-	-	-	653*
06-82	01/07/88		-	-	-	-	90 2
49-86	11/24/86		-	45(7)	-	-	-
	04/08/87		-	-	-	9 10	150*
	06/18/87		-	-	-	16 3	-
	08/25/87		-	-	-	12 6	-
	12/14/87		-	-	-	6.58	1340*
47-86	11/07/86		-	88(5 4)	-	-	-
09-81	08/14/86		-	85(10U)	-	-	-
45-86	10/16/86		-	110(12)	-	-	-
56-86	10/02/86		2 6	120(16)	-	-	-
	07/15/87		2 9	-	-	-	-

* Outlier

** ( ) HCO_3^- value

that indicates impact in the West Spray Field area Nitrate occurs at three times background in all subareas of the West Spray Field (Table 5-10)

In conclusion, nitrate is the most prevalent contaminant associated with the impact of the West Spray Field Sulfate and sodium are also elevated in many locations, but concentrations are seldom found above three times background

5 2 2 Bedrock Ground-water Flow System

Ground-water flow occurs in the Laramie Formation under confined conditions Unconfined flow within the Laramie Formation in the West Spray Field Area has not been documented to date and is not believed to exist

5 2 2 1 Recharge Conditions

Recharge to the Laramie Formation occurs as downward infiltration from the overlying Rocky Flats Alluvium Table 5-11 presents downward hydraulic gradients calculated for alluvial/bedrock well pairs in the West Spray Field area Calculated vertical gradients range from about 0 08 to 0 34 The presence of a downward gradient has been demonstrated previously at the Plant (Hurr, 1976 and Rockwell International, 1986a, Rockwell International, 1988a, 1988b, 1988c)

Figures 5-2, 5-3, and 5-4 illustrate the elevation of the potentiometric surface through time for well pairs 51-86/52-86, 49-86/48-86, and 47-86/46-86, respectively Three wells 51-86, 52-86, and 48-86, exhibit uncharacteristically spiky curves when first measured This may be due to ongoing well development and slow recovery after sampling

Figure 5-2:
ELEVATION OF THE POTENTIOMETRIC SURFACE FOR WELLS 47-86 and 46-86

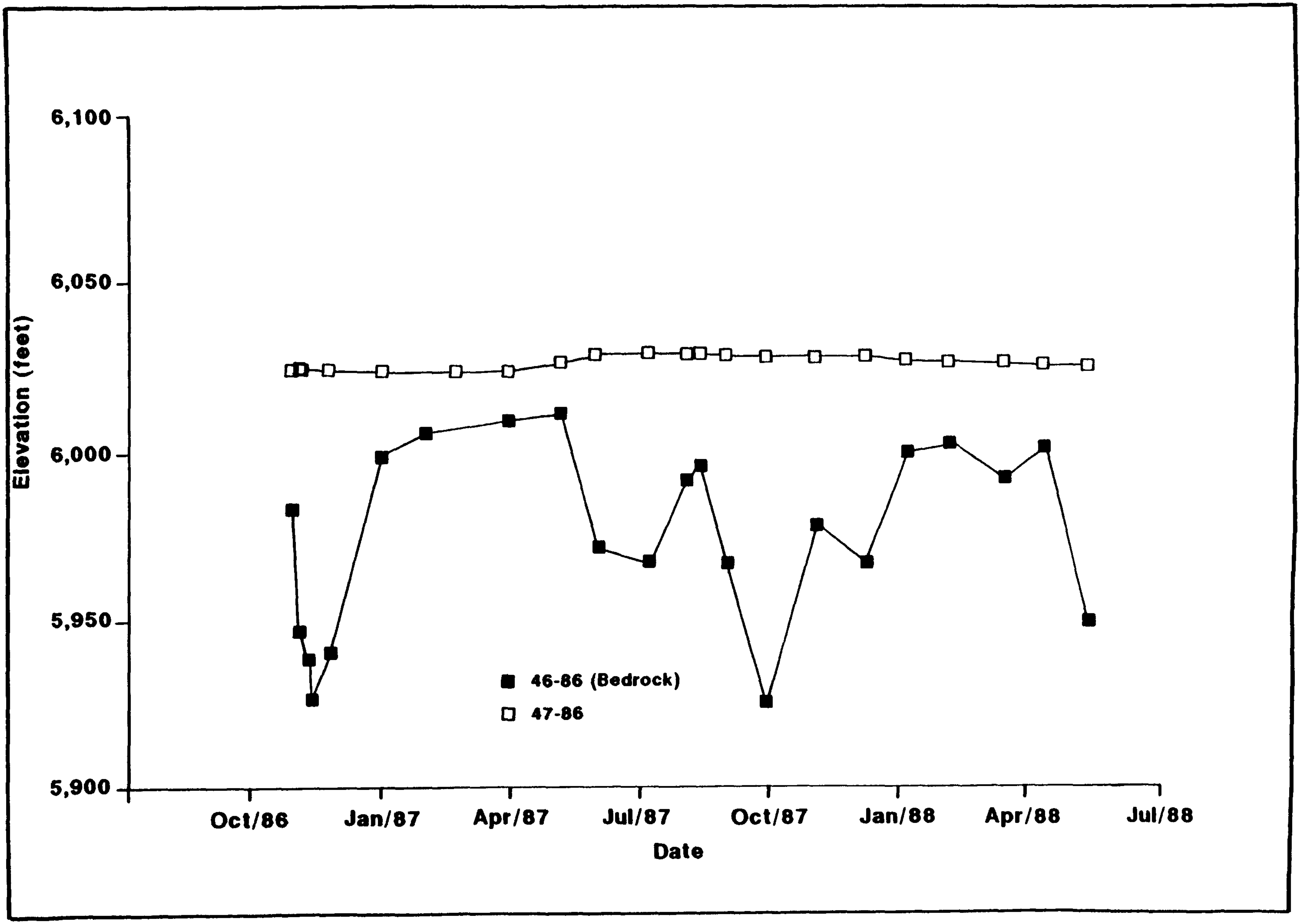


Figure 5-3:
ELEVATION OF THE POTENTIOMETRIC SURFACE FOR WELLS 49-86 and 48-86

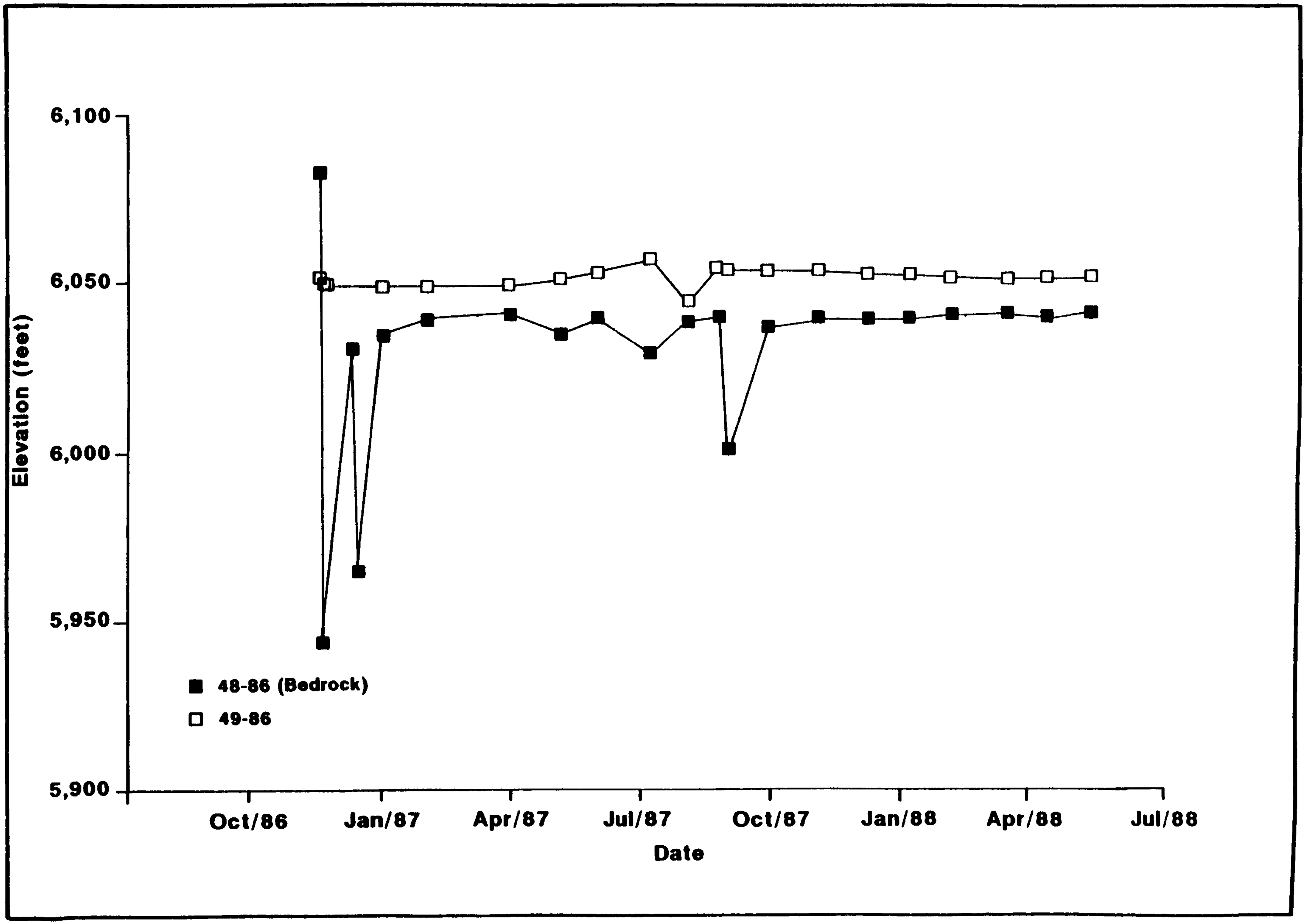


Figure 5-4:
ELEVATION OF THE POTENTIOMETRIC SURFACE FOR WELLS 51-86 and 52-86

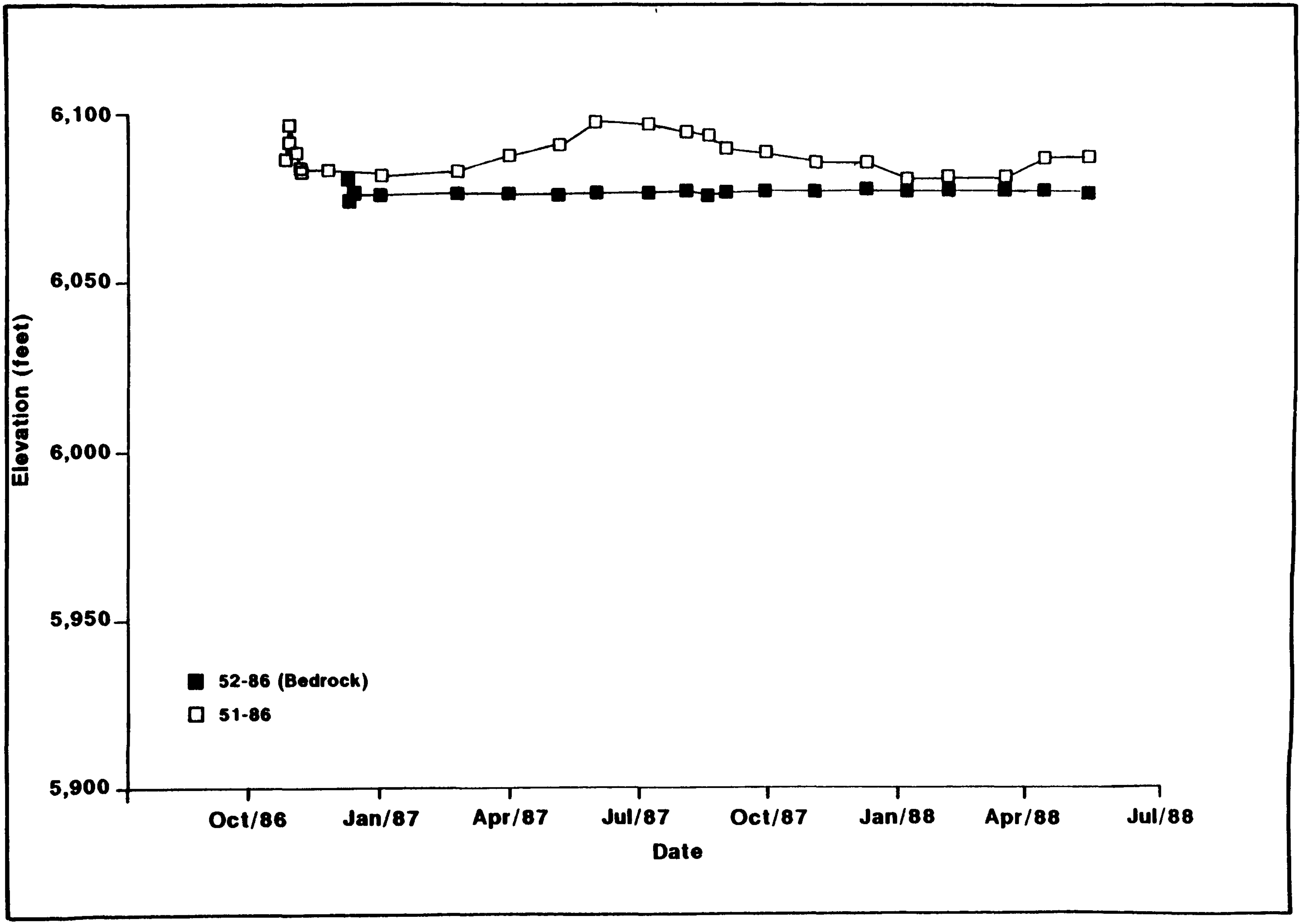


TABLE 5-11
VERTICAL HYDRAULIC GRADIENTS

Well	Elevation of Potentiometric Surfaced (Measured 04/11/88)	Water Level Difference (ft)	Elevation of Screened Interval (ft amsl)	Elevation of Saturated Interval Midpoint	Thickness of Separation (ft)	Downward Vertical Gradient (ft/ft)
46-86*	6001 29	25 49	5941 38 - 5920 92	5931 15	75 96	0 34
47-86	6026 78		6075 69 - 5987 43	6007 11		
48-86*	6040 15	11 75	5904 69 - 5882 61	5893 65	146 96	0 080
49-86	6051 90		6092 82 - 6029 32	6040 61		
51-86	6086 72	9 46	6137 46 - 6063 23	6074 98	41 58	0 23
52-86*	6077 26		6050 22 - 6016 57	6033 40		

* Completed in Bedrock

Wells 47-86, 49-86, and 51-86 are completed in Rocky Flats Alluvium As discussed in Section 5 2 1 1 of this report, the potentiometric surface (water table) in these wells varies in response to incident precipitation No correlation is apparent between the potentiometric surface exhibited by wells completed in the Rocky Flats Alluvium and any of wells completed in the Laramie Formation, wells 46-86, 48-86, and 52-86 Thus the Laramie Formation is apparently not directly recharged from incident precipitation

5 2 2 2 Ground-Water Flow Directions

None of the existing bedrock wells at the West Spray Field area are completed in the same unit of the Laramie Formation Consistent with the regional recharging of the Laramie Formation in this locality, it is assumed ground water flows eastward within the subcropping sandstone A hydraulic gradient of 0 03 ft/ft for subcropping Laramie sandstones is estimated from a 1978 regional potentiometric surface maps for the Laramie Formation (Robson et al, 1981b)

5 2 2 3 Hydraulic Conductivities

Hydraulic conductivity values for the Laramie Formation were estimated from a drawdown-recovery test performed in 1986, a slug test performed in 1988, and packer tests performed in 1986 Tables 5-12 and 5-13 summarize the results of these tests Data, analyses, and results of each test are provided in Appendix B

TABLE 5-12

RESULTS OF PACKER TESTS IN LARAMIE FORMATION

Well Number	Interval (Depth below Ground Level ft)	Lithology	1st P1/3 (cm/s)	P2/3 (cm/s)	2nd P1/3 (cm/s)	Geometric Mean (cm/s)
46-86	107 27-117.30	Claystone	3x10^{-8}	Aborted		3x10^{-8}
	130 22-140 25	Claystone	1x10^{-8}	1 7x10^{-7}	6x10^{-8}	5x10^{-8}
	140 64-150 67	Siltstone	1x10^{-8}	5 1x10^{-7}	1 1x10^{-7}	8x10^{-8}
	151 00-161 03	Siltstone	1x10^{-8}	7x10^{-8}	1x10^{-8}	2x10^{-8}
		Geometric Mean for Claystone				4x10^{-8}
		Geometric Mean for Siltstone·				4x10^{-8}
48-86	101 23-110 88	Siltstone & Claystone*	2x10^{-8}	Failed		
	113 80-123 53	Siltstone	1 6x10^{-7}	6x10^{-8}	1x10^{-8}	5x10^{-8}
	124 69-134 34	Siltstone	2 3x10^{-7}	7 0x10^{-7}	1 0x10^{-7}	2 5x10^{-7}
	128 05-137 70	Siltstone	3 8x10^{-7}	Failed		3 8x10^{-7}
	130 05-139 70	Siltstone	5 5x10^{-7}	Failed		5 5x10^{-7}
	141 03-150 39	Siltstone	9x10^{-8}	6 5x10^{-7}	3x10^{-8}	1 2x10^{-7}
	141 03-150 39	Siltstone	3 4x10^{-7}	Failed		3 4x10^{-7}
	144 00-153 65	Siltstone	2 5x10^{-7}	Failed		2 5x10^{-7}
	145 94-155 59	Siltstone	1 9x10^{-7}	Failed		1 9x10^{-7}
	160 00-169 65	Siltstone	4 3x10^{-7}	Failed		4 3x10^{-7}
	161 88-171 53	Siltstone	1 3x10^{-7}	Failed		1 3x10^{-7}
	165 20-174 80	Siltstone	1 0x10^{-7}	Failed		1 0x10^{-7}
	167 10-176 74	Siltstone	3 1x10^{-7}	Failed		3 1x10^{-7}
	175 85-185 50	Siltstone	2 2x10^{-7}	Failed		2 2x10^{-7}
	177 75-187 40	Siltstone	1x10^{-8}	Failed		1x10^{-8}
	181 21-190 86	Siltstone	1 5x10^{-7}	Failed		1 5x10^{-7}
	183 11-192 76	Siltstone	4x10^{-8}	Failed		4x10^{-8}
	192 00-201 65	Siltstone & Sandstone*	1x10^{-8}	Failed		
	194 00-203 60	Siltstone & Sandstone*	3 0x10^{-7}	Failed		
	196 15-206 80	Sandstone	1 1x10^{-7}	Failed		1 1x10^{-7}
	198 76-208 41	Sandstone	3x10^{-8}	Failed		3x10^{-8}
		Geometric Mean for Siltstone				1 6x10^{-7}
		Geometric Mean for Sandstone				6x10^{-8}

* Mixed lithology tests not used in calculating geometric means

TABLE 5-13

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS IN LARAMIE FORMATION

Well	Lithology	Hydraulic Conductivities Drawdown Recovery Test (cm/s)	Slug Test (cm/s)	Packer Test (cm/s)	Ground Water Velocity* (ft/yr)
46-86	Claystone			$4x10^{-8}$	0.013
	Siltstone	$5x10^{-8}$		$4x10^{-8}$	0.017,0.013
48-86	Siltstone & Sandstone		$5.4x10^{-7}$		0.18
	Siltstone			$1.6x10^{-7}$	0.053
	Sandstone			$6x10^{-8}$	0.020
	Geometric Mean (cm/s)				
	Sandstone:			$6x10^{-8}$	0.020
	Siltstone:	$5x10^{-8}$		$8x10^{-8}$	0.017,0.026
	Claystone:			$4x10^{-8}$	0.013

* Horizontal ground-water velocity. Velocities are calculated from the hydraulic conductivity, the average horizontal gradient of 0.033 ft/ft, and an assumed effective porosity of 0.1. The equation used is

G-W Velocity (ft/yr) = K($1.0x10^6$ ft-sec/cm-yr)(0.033 ft/ft)/(0.1)

where K = hydraulic conductivity (cm/s)

The hydraulic conductivity calculated for sandstone is 6 x 10^{-8} cm/s, for claystone 4 x 10^{-8} cm/s, and for siltstone 5 x 10^{-8} and 1 6 x 10^{-7} cm/s A slug test of an interval comprised of 5 feet siltstone and 10 feet clayey sandstone yielded a slightly higher hydraulic conductivity of 5 4 x 10^{-7} cm s

The horizontal ground-water flow velocity for the Laramie Formation in the West Spray Field area varies from 0 013 to 0 18 ft/year See Table 5-4 for details

5 2 2 4 Bedrock Ground-Water Quality

Basis for Background Bedrock Ground-Water Quality

Unlike alluvial ground water, the bedrock ground-water quality is unlikely to be impacted by the West Spray Field because of the claystone separation of bedrock sandstones from alluvium Background bedrock ground-water quality was previously established and described in the 881 Hillside Remedial Investigation Report, March 1988 (Rockwell International, 1988) Data from wells completed in the sandstone of the Laramie Formation (46-86, 48-86, 52-86, and 54-86) were used to establish background bedrock ground water quality, however, all of these bedrock wells except 54-86 are located within the West Spray Field Therefore, bedrock background conditions are characterized in this document as concentration ranges observed for bedrock well 54-86 located south of the West Spray Field As with the alluvial background range, outliers are excluded in developing the background range

Ground water in the bedrock west of the Plant is of excellent quality, characterized by low concentrations of major ions, metals and radionuclides Organic compounds are non-detectable and pH ranges from 5 5 to 10 6 Analytical data are presented in Appendix D, and a summary of the determined background ranges is presented in Table 5-14

METALS

Metal concentrations in the bedrock ground water are generally low Fourteen of the twenty-three metals for which analyses are made were not detected above the detection limits

1 Antimony (0 02 mg/l)
2 Arsenic (0 01 mg/l)
3 Beryllium (0 005 mg/l)
4 Cadmium (0 005 mg/l)
5 Cesium (0 02 mg/l)
6 Cobalt (0 022 mg/l)
7 Lithium (0 1 mg/l)
8 Mercury (0 0002 mg/l)
9 Molybdenum (0 022 mg/l)
10 Nickel (0 037 mg/l)
11 Selenium (0 005 mg/l)
12 Silver (0 0076 mg/l)
13 Thallium (0 01 mg/l)
14 Vanadium (0 024 mg/l)

The detection limits are considered the maximum reasonable values for background conditions

Background ranges were established for the other nine metals as follows

1 Aluminum concentrations varied from below the detection limit of 0 029 mg/l to a maximum concentration of 0 15 mg/l This value is an outlier according to Dixon's Test Therefore, the detection limit is considered background for aluminum

2 Barium concentrations varied uniformly between 0 057 mg/l and 0 106 mg/l, the entire range is considered reasonable for background conditions

3 Chromium was generally not detected above the detection limit of 0 01 mg/l, however, the maximum detected value (0 015 mg/l) is near the detection limit and is therefore included in the range of reasonable background values

TABLE 5-14

BACKGROUND BEDROCK
GROUND-WATER QUALITY
AND PROPOSED GROUND-WATER CONCENTRATION LIMITS

	Element	Concentration Range (mg/l) Background*	Proposed Ground-water Concentration Limits
METALS			
	Aluminum	029U	5 0
++	Antimony	02U	0 02U
+	Arsenic	01U	0 05
+	Barium	057- 106	1 0
++	Beryllium	005U	0 005
+	Cadmium	005U	0 01
	Cesium	02U	0 02U
+	Chromium	01U- 015	0 05
++	Cobalt	022U	0 022U
++	Copper	0063U- 048	0 048
	Iron	0069U- 011	0 3
+	Lead	005U- 019	0 05
++	Lithium	1U	0 1U
	Manganese	026- 228	0 05
+	Mercury	0002U	0 002
	Molybdenum	022U	0 1
++	Nickel	037U	0 037U
+	Selenium	005U	0 01
+	Silver	0076U	0 05
	Strontium	33- 87	0 87
++	Thallium	01U	0 01U
++	Vanadium	024U	0 024
++	Zinc	02U- 05	0 05
RADIONUCLIDES		Concentration Range (pci/l)	
	Gross Alpha	Below MDA-57(32)	15
	Gross Beta	Below MDA-65(48)	50
	Uranium 233,234	Below MDA-2 4(1 3)	40 ***
	Uranium 235	Below MDA	40 ***
	Uranium 238	Below MDA- 64(13)	40 ***
	Plutonium 239,240	Below MDA	40
	Americium 241	Below MDA- 048(045)	4
	Strontium 89,90	Below 1 02	8
	Tritium	Below 593	20,000

TABLE 5-14
(CONTINUED)
BACKGROUND BEDROCK
GROUND-WATER QUALITY
AND PROPOSED GROUND-WATER CONCENTRATION LIMITS

	Element	Concentration Range (mg/l) Background	Proposed Ground-water Concentration Limit
MAJOR IONS			
	Calcium	43-111	NA
	Magnesium	10-25	NA
	Potassium	5U-6	NA
	Sodium	32-37	NA
	Bicarbonate	246-347	NA
	Carbonate	ND	NA
	Chloride	8-24	250
	Nitrate	ND	10
	Sulfate	41-52	250
	Total Dissolved Solids	425-467	400

* Plant background water quality conditions (Rockwell International, 1988)
*** Total Uranium
\+ SDWA metal and Appendix IX hazardous constituents
++ Appendix IX hazardous constituent that is not an SDWA metal
NA Not available
MDA Theoretical Minimum Detectable Activity
U Values less than Detection Limit
ND Non-Detectable

4 Copper concentrations varied from below the detection limit of 0 0063 mg/l to 0 048 mg/l Because of the uniformity of the distribution within the range, the entire range is considered reasonable for background conditions

5 Iron concentrations varied from below the detection limit of 0 0069 mg/l to 0 11 mg/l The value 0 11 mg/l is an outlier by Dixon's test, therefore, the background range is established as less than 0 0069 mg/l to 0 011 mg/l

6 Lead was generally not detected above the detection limit of 0 005 mg/l, however, the maximum detected value (0 019 mg/l) is within an order of magnitude of the detection limit and is therefore included in the range of reasonable background values

7 Manganese concentrations varied uniformly between 0 026 mg/l and 0 228 mg/l, the entire range is considered reasonable for background conditions

8 Strontium concentrations, like manganese, varied uniformly between 0 33 mg/l to 0 87 mg/l, the entire range is considered reasonable for background conditions

9 Zinc concentrations varied from below the detection limit of 0 02 mg/l to 0 05 mg/l Because of the uniformity of the distribution within the range, the entire range is considered reasonable for background conditions

RADIONUCLIDES

Background bedrock ground water contains low concentrations of radionuclides As with the background alluvial ground-water quality, plutonium and uranium 235 concentrations generally have uncertainties associated with the determination that are on the order of the determination itself As discussed earlier in the background alluvial ground water section, this is similar to non-detectable concentrations of other parameters

Both uranium-234 and -238 were often determined at concentrations exceeding the associated uncertainty Uranium-234 determinations were in the range of less than the MDA to 6 6±1 8 pCi/l, and uranium-238 determinations were in the range of less than the MDA to 4 4±1 5 pCi/l Both the 6 6 and 4 4 values are outliers by Dixon's Test (and occurred in 1986) The background range for uranium-234 is established as less than the MDA to 2 4 (1 3) pCi/l, and for uranium-238 less than the MDA to 0 64 (0 13) pCi/l

MAJOR IONS

TDS is generally low in background bedrock ground water (ranging from approximately 425 to 467 mg/l) The range of reasonable background major ion concentrations include all determinations of samples collected from bedrock well 54-86, because the results were uniformly distributed over the ranges The concentration ranges presented in Table 5-14 indicate that the major ion chemistry of background bedrock ground water is dominated by calcium and bicarbonate Concentrations of specific cations and anions that make up the majority of the TDS are as follows

Cations

1 Calcium concentrations ranged from 43 to 111 mg/l in bedrock well 54-86

2 Magnesium concentrations were of consistent magnitude in all wells, ranging from 10 to 25 mg/l

3 Potassium concentrations varied from below the detection limit of 5 mg/l to a maximum concentration of 6 mg/l Because the highest detection in the background well is so low, the entire range of less than 5 to 6 mg/l is presented on Table 5-14

4 Sodium concentrations were of consistent magnitude in all of the samples, ranging from 32 to 37 mg/l

Anions

1 Bicarbonate and carbonate ranged from 246 to 347 mg/l and non-detectable for bicarbonate and carbonate, respectively Given the pH ranges are below 8 3, any carbonate is considered abnormal Therefore, appropriate background concentrations are considered to be those shown above

2 Chloride concentrations ranged from 8 to 24 mg/l

3 Nitrate concentrations were all below the detection limit of 0 20 mg/l and this is considered the background bedrock ground water upper limit

4 Sulfate concentrations generally ranged from 41 to 52 mg/l, with the exception of one sample analyzed on 02/08/88 of 92 mg/l This value is considered an outlier by Dixon's Test

OVERVIEW

Three bedrock wells are used to categorize the potential impact of the West Spray Field on bedrock ground-water chemistry All these are screened in the Laramie Formation Well 52-86 is located upgradient to the west of the area Well 48-86 lies within the central portion of the West Spray Field and well 46-86 lies to the north and is sidegradient to the potentially impacted

Ground water in the bedrock does not appear to be impacted by the activities at the West Spray Field Barium is elevated in most samples collected from well 46-86 (Table 5-15) Molybdenum is above background in all samples analyzed in Well 52-86 However, these metals are not above three times background (Table 5-18) Iron and aluminum are elevated above three times background in one sample (05/14/87) from well 46-86 All of these observed metal concentrations probably represent natural bedrock ground water geochemical variation, and are not the result of the impact of the West Spray Field

TABLE 5-15
METAL CONCENTRATIONS ABOVE BACKGROUND IN BEDROCK WELLS (mg/l)

Well Number	Date Sampled	Al	Ba	Fe	Pb	Mo	Hg	Se	V	Zn
Background	-------------	0 029U	0 106	0 011	0 019	0 022U	0 0002U	0 005U	0 24U	0 04
46-86	11/13/86	0 350	0 144	0 132	-	-	-	0 009	-	-
	05/14/87	0 7932	0 2010	0 5391	-	-	-	-	-	-
	06/22/87	-	0 1498	-	-	0 0244	0 0003	-	-	-
	08/14/87	-	0 2224	-	-	0 0224	-	-	-	-
	10/05/87	-	0 1851	-	-	-	-	-	-	-
	10/06/87	-	-	-	-	-	-	-	-	-
	02/12/88	-	0 1642	-	-	-	-	-	-	-
48-86	04/08/87	-	-	-	-	0 0327	-	-	-	0 09
	06/18/87	-	-	-	0 029	-	-	-	-	-
	08/25/87	-	0 1318	-	-	-	-	-	-	-
	12/14/87	-	-	-	-	-	-	-	-	-
52-86	05/13/87	-	-	-	-	-	-	-	-	-
	06/18/87	-	-	-	-	-	-	-	-	-
	08/19/87	-	-	-	-	0 0553	-	-	-	-
	10/02/87	-	-	-	-	0 0401	-	-	-	-
	10/02/87(Dup)	-	-	-	-	0 0415	-	-	-	
	10/02/88(Dup)	-	-	-	-	-	-	-	-	-
	02/08/88	-	-	-	-	0 0398	-	-	-	0 0947

The radionuclide concentrations elevated above background (Table 5-16) all appear randomly, are outliers, or represent natural variations in the bedrock ground-water quality

Sodium occurred above background in all samples collected from well 48-86 (Table 5-17) However, none of the major ions were elevated above three times background in the bedrock wells of the West Spray Field Area (Table 5-18)

TABLE 5-16

RADIONUCLIDE CONCENTRATIONS ABOVE BACKGROUND IN BEDROCK WELLS (pCi/l)

Well Number	Date Sampled	Gross Alpha 57(32)	Gross Beta 65(48)	U 235 MDA	U 238 4 4(1 5)	Sr 89,90 (1 02)	Pu 239,240 MDA
46-86	11/13/86	-	-	-	-	-	-
	05/14/87	184(33)	95(5)	50(42)	-	5 04	-
	06/22/87	-	-	-	-	-	-
	08/14/87	-	-	-	7 5(1 7)	1 9	-
	10/05/87	-	-	09(06)	-	-	-
	10/06/87	-	-	-	-	-	-
	02/12/87	-	-	-	-	-	-
48-86	04/08/87	-	-	-	-	-	-
	06/18/87	-	67(22)	-	-	-	-
	08/25/87	-	-	-	-	3 7	-
	12/14/87	-	-	05(04)	-	-	-
52-86	05/13/87	-	-	-	-	-	-
	06/18/87	-	-	-	-	-	-
	08/19/87	-	-	-	-	-	1 8(1 3)
	10/02/87	-	-	-	-	-	-
	10/02/87(Dup)	-	-	-	-	-	-
	10/02/87(Dup)	-	-	-	-	-	-
	02/08/88	-	-	-	-	-	-

MDA - Theoretical minimum detectable activity

TABLE 5-17

MAJOR ION CONCENTRATIONS ABOVE BACKGROUND IN BEDROCK WELLS (mg/l)

Well Number	Date Sampled	K^+	Na^+	CO_3^{-*}	NO_3^-	$SO_4^=$
Background	---------------	6	37	ND	ND	92
46-86	11/13/86	7 2	-	-	-	-
	05/14/87	-	-	-	0 54	-
	06/22/87	8 0	-	-	-	-
	08/14/87	-	37.7556	-	-	-
	10/05/87	-	-	-	-	-
	10/06/87	-	-	-	-	-
	02/12/88	-	-	-	-	-
48-86	04/08/87	-	37 2643	-	-	96 0
	06/18/87	-	45 4743	-	-	-
	08/25/87	-	46 7407	-	-	-
	12/14/87	-	42 0372	-	-	-
52-86	05/13/87	-	-	-	-	-
	06/18/87	-	-	-	-	-
	08/19/87	-	-	2 0(35 6)	-	-
	10/02/87	-	-	13 4(24 4)	-	-
	10/02/87(Dup)	-	-	18 5(23 4)	-	-
	10/02/87(Dup)	-	-	-	-	-
	02/08/88	-	-	-	-	-

* ( ) HCO_3^- Value

TABLE 5-18

ANALYTE CONCENTRATIONS ABOVE THREE TIMES BACKGROUND IN BEDROCK WELLS

Well Number	Date Sampled		Al	Fe	Gross Alpha	U^{235}	$Sr^{89,90}$	$CO_3^{=}$
		Background	0 15	0 11	57(32)	MDA	1 02	5U
		3xBackground	0 45	0 33	171		3 06	15
			(mg/l)	(mg/l)	(pCi/l)	(pCi/l)	(pCi/l)	(mg/l)
46-86	05/14/87		0 7932	0 5391	184(33)*	0 50(0 42)	5 04	-
	10/05/87		-	-	-	0 90(0 06)	-	-
48-86	08/25/87		-	-	-	-	3 7	-
	12/14/87		-	-	-	0 05(0 04)	-	-
52-86	10/02/87		-	-	-	-	-	18 5
	10/02/87(Dup)		-	-	-	-	-	-

* Outlier

SECTION 6

REFERENCES

Agricultural Stabilization and Conservation Service, 1969, Flight No AIN-1KK Photo No 152 to 156 and 161 to 165, August 7, 1969

Boulder County Planning Commission, 1983, Boulder County Comprehensive Plan - Geology Element, Boulder County Land Use Department

Bouwer, H, 1978, Groundwater Hydrology, McGraw-Hill Inc, New York, New York

Bouwer, H, and R C Rice, 1976, A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells American Geophysical Union, Vol 12 No 3, pp 423-428

Colorado Aerial Photo Service, 1968, Flight No 129 Photo No 385 to 387, April 10, 1968

Colorado Aerial Photo Service, 1970, Flight No 132, Photo No 25, April 15, 1970

Colorado Aerial Photo Service, 1972, Flight No 135, Photo No 17 to 19 and 93 to 95, April 24, 1972

Colorado Aerial Photo Service, 1974, Flight No 140, Photo No 19 and 20, April 27, 1974

Colorado Aerial Photo Service, 1975, Flight No 142, Photo No 27 and 28, October 15, 1975

Colorado Aerial Photo Service, 1976, Flight No 144, Photo No 19 and 20, October 8, 1976

Colorado Aerial Photo Service, 1977, Flight No 146, Photo No 26 and 27, October 12, 1977

Colorado Aerial Photo Service, 1978, Flight No 148, Photo No 10 and 11, October 15, 1978

Colorado Aerial Photo Service, 1979, Photo No 80 to 82, May 12, 1979

Colorado Aerial Photo Service, 1980, Photo No 22 to 25 October 19 1980

Colorado Aerial Photo Service, 1981, Photo No 59 to 61 October 19 1981

Colorado Aerial Photo Service, 1982 Photo No 34 and 35 October 4 1982

Colorado Aerial Photo Service, 1983 Photo No 53 and 54 October 5 1983

Colorado Aerial Photo Service, 1984, Photo No 32 and 33, November 18, 1984

Colorado Aerial Photo Service, 1985, Photo No 36 and 37, October 5, 1985

Colorado Department of Health, 1979, letter to Rockwell International

Costa, J E and S W Bilodeau, 1982, Geology of Denver, Colorado United States of America Bulletin of the Association of Engineering Geologists, Vol XIX, No 3 pp 261-314

Dames and Moore, 1981, Geologic and Seismologic Investigations for Rocky Flats Plant, Contract DE-AC04-80A110890

DOE, 1980, Final Environmental Impact Statement Rocky Flats Plant Site, Golden Jefferson County, Colorado, Volumes 1, 2, and 3, U S Department of Energy Report, Washington, D C, DOE/EIS-0064

Driscoll F G, 1986, Groundwater and Wells, Johnson Division, St Paul, Minnesota, 1089 p

Epis R C and C E Chapin, 1975 "Geomorphic and Tectonic Implications of the Post-Laramide, Late Eocene Erosion Surface in the Southern Rocky Mountains", in Cenozoic History of the Southern Rocky Mountains, Curtis, B F (ed), Geologic Society of America Memoir 144, pp 45-74

Fenneman, N M, 1931, Physiography of Western United States, McGraw Hill Book Company, New York, 534 p

Geological Society of America, 1984, Rock-Color Chart

Grose, L T, 1972 Tectonics in Geologic Atlas of the Rocky Mountain Region, W W Mallory (ed), Rocky Mountain Association of Geologists, pp 35-44

Henry, R L, 1986, Trends Observed in Rocky Flats Surface Water Monitoring, Rockwell International Environmental Analysis and Control

Hurr, R T, 1976, Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado, U S Geological Survey Open-File Report 76-268

Hydro-Search, Inc, 1985, Hydrogeologic Characterization of the Rocky Flats Plant, Golden, Colorado, Project No 1520, December 9, 55 p

Kent, H C, 1972, Review of Phanerozoic History, in Geologic Atlas of the Rocky Mountain Region, W W Mallory (ed) Rocky Mountain Association of Geologists pp 57-59

Kirkham, R M and W P Rogers 1981 Earthquake Potential in Colorado a Preliminary Evaluation, Colorado Geological Survey Bulletin 43

Leroy, L W, and R J Weimer 1971 Geology of the Interstate 70 Road Cut Jefferson County Colorado, Colorado School of Mines Prof Contrib No 7

Lord and Associates, 1977, Proposed Landfill Expansion Rocky Flats Jefferson County, Colorado

Martin, C A, 1965, Denver Basin Bulletin of the American Association of Petroleum Geologists, Vol 49, No 11, pp 1908-1925

Robinson, P, 1972, Tertiary History, in Geologic Atlas of the Rocky Mountain Region, W W Mallory (ed), Rocky Mountain Association of Geologists, pp 233-242

Robson, S G , 1987, Bedrock Aquifers in the Denver Basin, Colorado - a Quantitative Water-Resources Appraisal, U S Geological Survey Professional Paper 1257

Robson S G , J C Romero, and S Zawistowski, 1981a Geologic Structure Hydrology, and Water Quality of the Arapahoe Aquifer in the Denver Basin, Colorado U S Geological Survey Atlas HA-647

Robson, S G , A Wazinski, S Zawistowski, and J C Romero 1981b, Geologic Structure, Hydrology, and Water Quality of the Laramie-Fox Hills Aquifer in the Denver Basin, Colorado U S Geological Survey Hydrologic Atlas HA-650

Rockwell International, 1975, Annual Environmental Monitoring Report January-December 1974 Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-74

Rockwell International, 1976, Annual Environmental Monitoring Report January-December 1975, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-75

Rockwell International, 1977, Annual Environmental Monitoring Report January-December 1976, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-76

Rockwell International, 1978, Annual Environmental Monitoring Report January-December 1977, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-77

Rockwell International, 1979, Annual Environmental Monitoring Report January-December 1978, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-78

Rockwell International, 1980, Annual Environmental Monitoring Report January-December 1979, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-79

Rockwell International, 1981, Annual Environmental Monitoring Report January-December 1980, Rockwell International Rocky Flats Plant Golden Colorado report RFP-ENV-80

Rockwell International, 1982, Annual Environmental Monitoring Report January December 1981, Rockwell International Rocky Flats Plant Golden Colorado report RFP-ENV-81

Rockwell International, 1983, Annual Environmental Monitoring Report January-December 1982, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-82

Rockwell International, 1984, Annual Environmental Monitoring Report January-December 1983, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-83

Rockwell International, 1985, Annual Environmental Monitoring Report January-December 1984, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-84

Rockwell International, 1986a, Resource Conservation and Recovery Act Part B - Post-Closure Care Permit Application for U S DOE Rocky Flats Plant Hazardous and Radioactive Mixed Wastes, U S Department of Energy, unnumbered report

Rockwell International, 1986b, Draft Preliminary Prioritization of Sites, U S Department of Energy, Rocky Flats Plant, Golden, Colorado

Rockwell International, 1986c, Draft Project Operations Plan, Geological and Hydrological Site Characterization, U S Department of Energy, Rocky Flats Plant, Golden, Colorado

Rockwell International, 1986d, Draft Work Plan, Geological and Hydrological Site Characterization, U S Department of Energy, Rocky Flats Plant, Golden, Colorado

Rockwell International 1986e, Annual Environmental Monitoring Report, January-December 1985, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-84

Rockwell International, 1987a, Annual Environmental Monitoring Report January-December 1986, Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-86

Rockwell International, 1987b, 903 Pad, Mound, and East Trenches Areas Remedial Investigation Report, U S Department of Energy, Rocky Flats Plant, Golden, Colorado

Rockwell International, 1988a, Remedial Investigation Report for High Priority Sites (881 Hillside Area), U S Department of Energy, Rocky Flats Plant, Golden, Colorado, March 1988

Rockwell International, 1988b, Solar Evaporation Ponds, Hydrogeologic Characterization Report, Rocky Flats Plant, Golden Colorado Appendix 6 in "Solar Evaporation Ponds, Closure Plan," U S Department of Energy Rocky Flats Plant, Golden, Colorado, July 1, 1986

Rockwell International, 1988c Present Landfill Hydrogeologic Characterization Report, Rocky Flats Plant, Golden Colorado Appendix 6 in Present Landfill Closure Plan," U S Department of Energy Rocky Flats Plant Golden Colorado July 1 1988

Scharf & Associates, 1986, Flight No 153 65, Photo No 75005PB-1-1 to 75005PB-9-16, May 21 1986

Scott, G R, 1960, "Quaternary Sequence East of the Front Range Near Denver Colorado", in Guide to Geology of Colorado, by Weimer, R J and J D Haun (eds), Geological Society of America, Rocky Mountain Association Geologists, Colorado Scientific Society, pp 206-211

Scott G R, 1965, "Nonglacial Quaternary Geology of the Southern and Middle Rocky Mountains", in The Quaternary of the United States, Princeton University Press, pp 243-254

Scott, G R, 1970, Quaternary Faulting and Potential Earthquakes in East-Central Colorado U S Geological Survey, Prof Paper 700-C, pp C11-C18

Scott, G R, 1975, Cenozoic Surfaces and Deposits in the Southern Rocky Mountains in Cenozoic History of the Southern Rocky Mountains, Curtis, B F (ed), Geological Society of America Memoir 144, pp 227-248

Tracer Research Corporation, 1986, Shallow Soil Gas Investigation of the Rocky Flats Plant, Golden, Colorado

U S Department of Agriculture, 1983, Soil Survey of Golden Area, Colorado, Soil Conservation Service, 405 p

U S Geological Survey, 1971, Flight No GS-VCUC, Photo No 2-28 to 2-30, 20\-87 to 2-90, and 2-103 to 2-105, August 6, 1971

Van Horn, R, 1976, Geology of the Golden Quadrangle, Colorado, U S Geological Survey Prof Paper 872, p 116

Weimer, R J, 1973, A Guide to Uppermost Cretaceous Stratigraphy, Central Front Range, Colorado Deltaic Sedimentation, Growth Faulting and Early Laramide Crustal Movement, Mt Geol, Vol 10, No 3, pp 53-97

Witkind I J, 1976, Preliminary Map showing known and suspected active faults in Colorado U S Geological Survey Open File Report 76-154

Woodward-Clevenger & Associates, Inc, January 17, 1974, Geotechnical Services, Proposed and Existing Landfills, Dow Chemical Rocky Flats Plant, Near Golden, Colorado, Job No 17536-350

Zeff and Sealy, Inc, June 26, 1974, Proposed Sanitary Landfill Renovation, Dow Chemical Company

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000294

Titled: Plate 5-1: Rocky Flats Plant Monitor Well Locations

Fiche location: A-SW-M15

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000294

Titled: Plate 5-2: West Spray Field Characterization Report Monitoring Well and Sampling Locations, Spray Applications Areas, Cross Section Location Lines, and Sandstone Subcroppings (Plain View) MAP

Fiche location: A-SW-M15

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000294

Titled: Plate 5-3' West Spray Field Characterization Report Fence Diagram of Test Pits

Fiche location: A-SW-M15

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000294

Titled: Plate 5-5' West Spray Field Characterization Report Cross Sections A-A', B-B', C-C', and D-D'

Fiche location: A-SW-M15

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000294

Titled: Plate 5-7' West Spray Field Characterization Report Water Table Within Surficial Materials June-1987

Fiche location: A-SW-M16

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000294

Titled: Plate 5-9. West Spray Field Characterization Report Water Table Within Surficial Materials November-1987

Fiche location: A-SW-M16

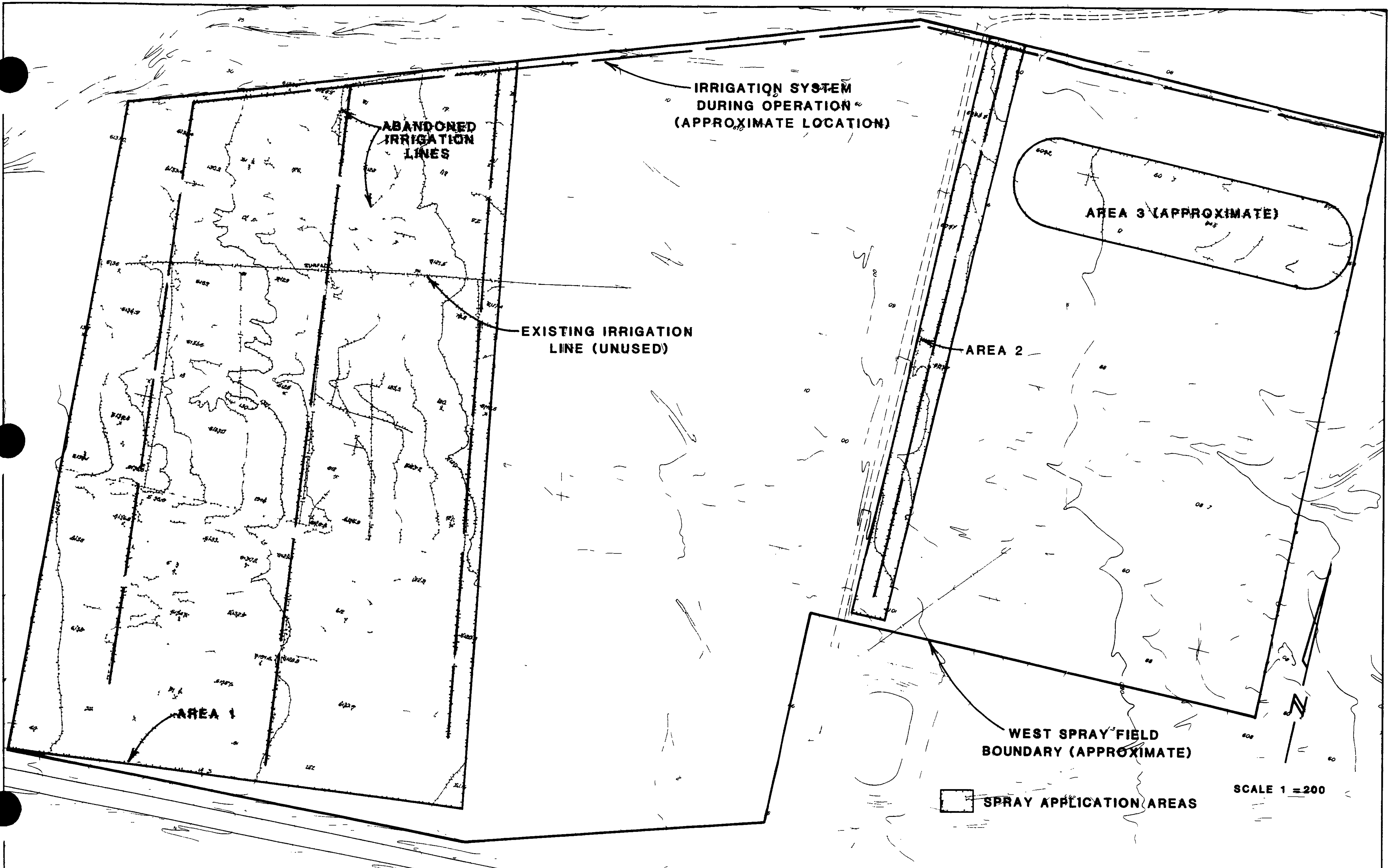
NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

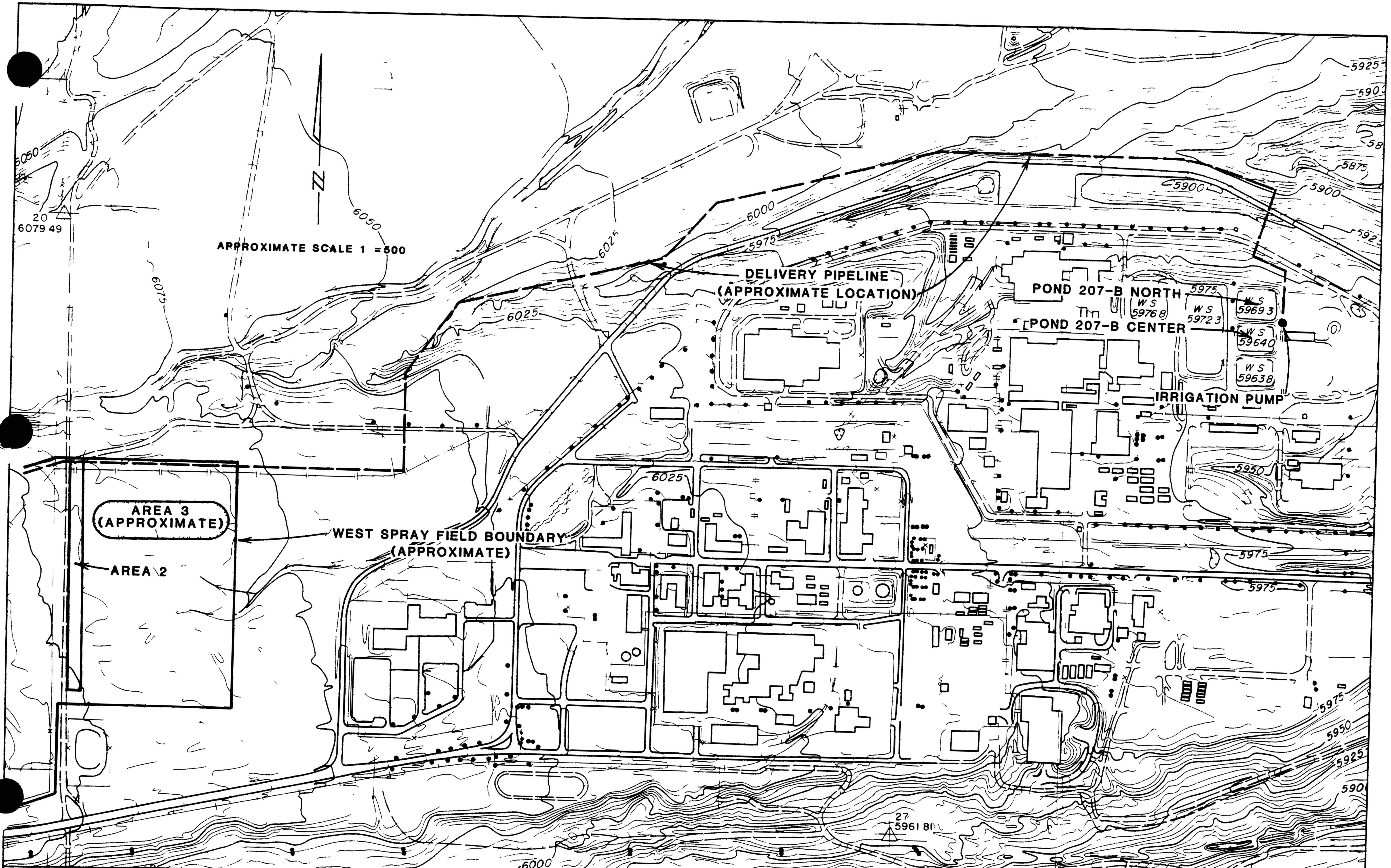
Document # 000294

Titled: Plate 5-10: West Spray Field Characterization Report Water Table Within Surficial Materials APRIL-1988

Fiche location: A-SW-M16

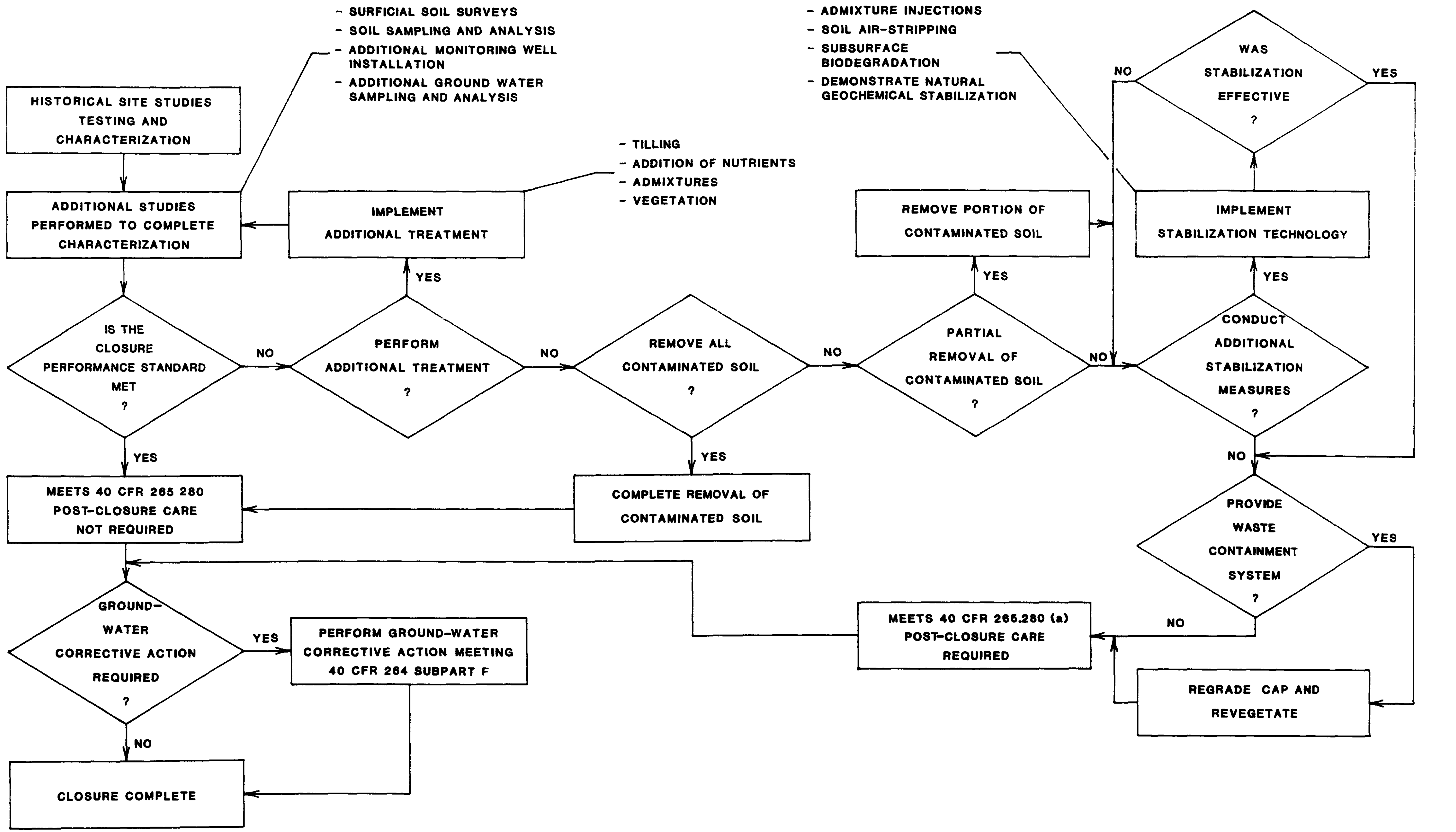


6 064 87	Chen & Associates	LOCATION MAP	Fig 1-3

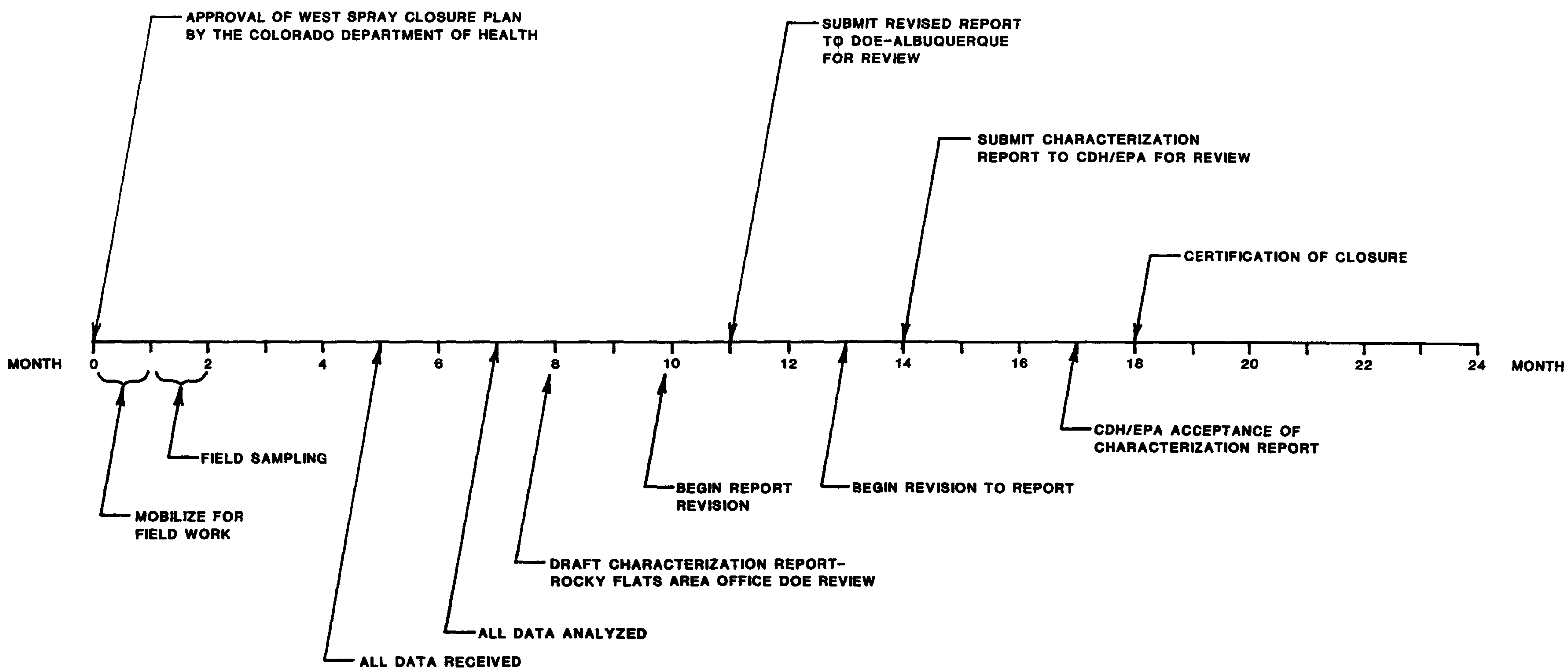


6 064 87 | Chen & Associates

GENERAL DELIVERY SYSTEM LAYOUT | Fig 1-4



6 064 87 | Chen & Associates | CLOSURE PLAN ACTIVITY FLOW DIAGRAM | Fig 1-5



6 064 87	Chen & Associates	SCHEDULE OF CLOSURE ACTIVITIES	Fig 1-6

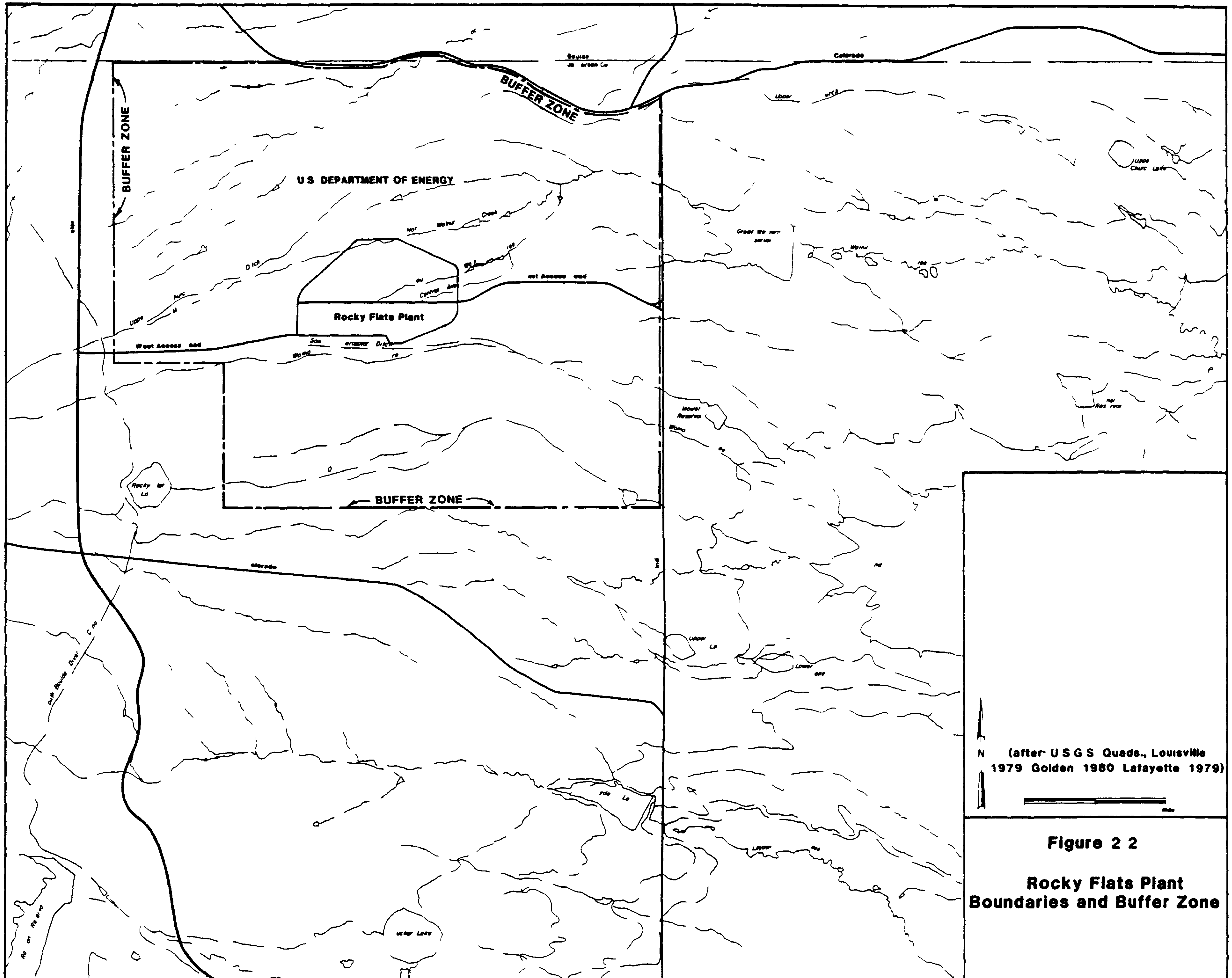


Figure 2 2

Rocky Flats Plant Boundaries and Buffer Zone

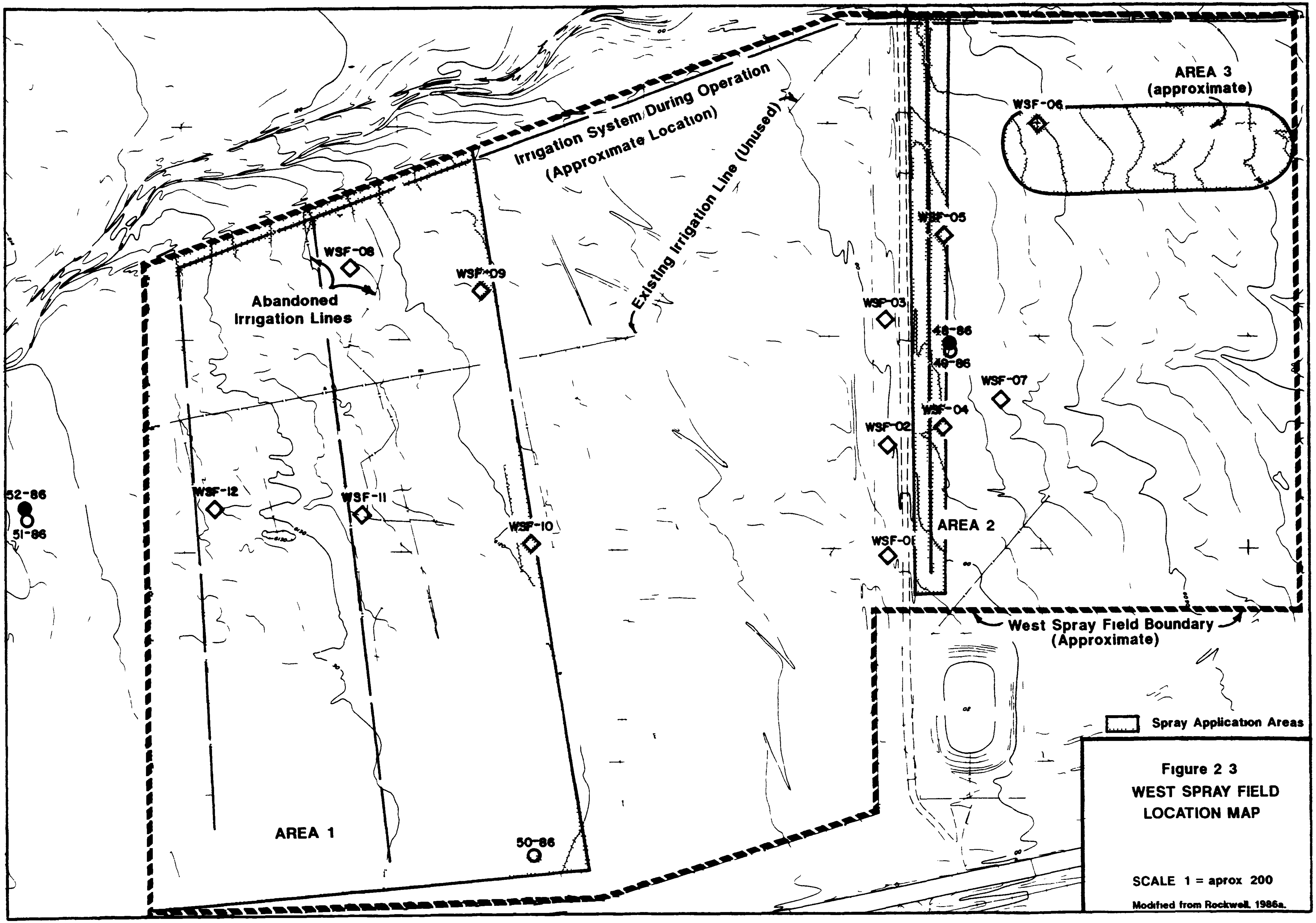
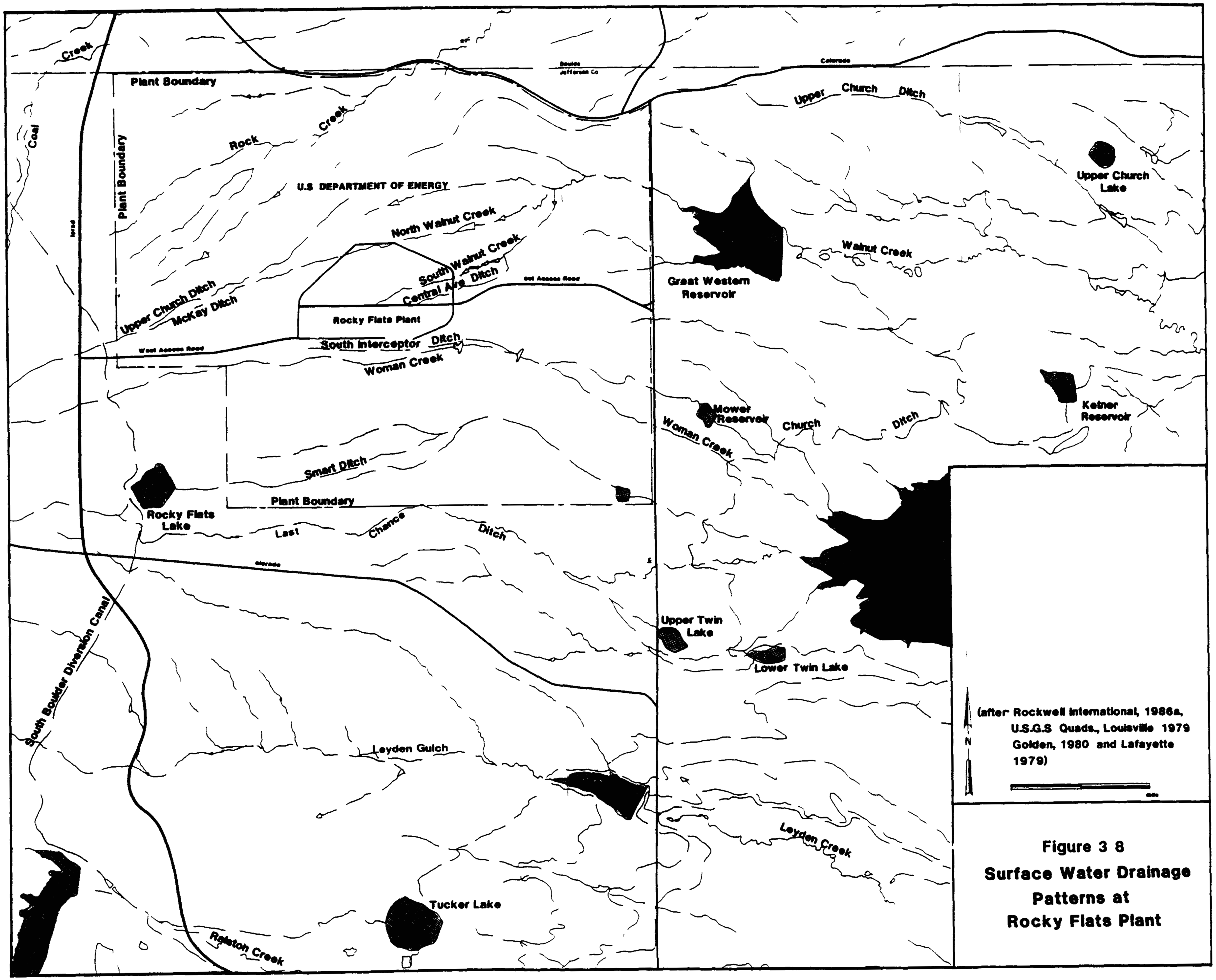


Figure 2 3
WEST SPRAY FIELD
LOCATION MAP

SCALE 1 = aprox 200

Modified from Rockwell, 1986a.



(after Rockwell International, 1986a, U.S.G.S Quads., Louisville 1979 Golden, 1980 and Lafayette 1979)

Figure 3 8
Surface Water Drainage Patterns at Rocky Flats Plant

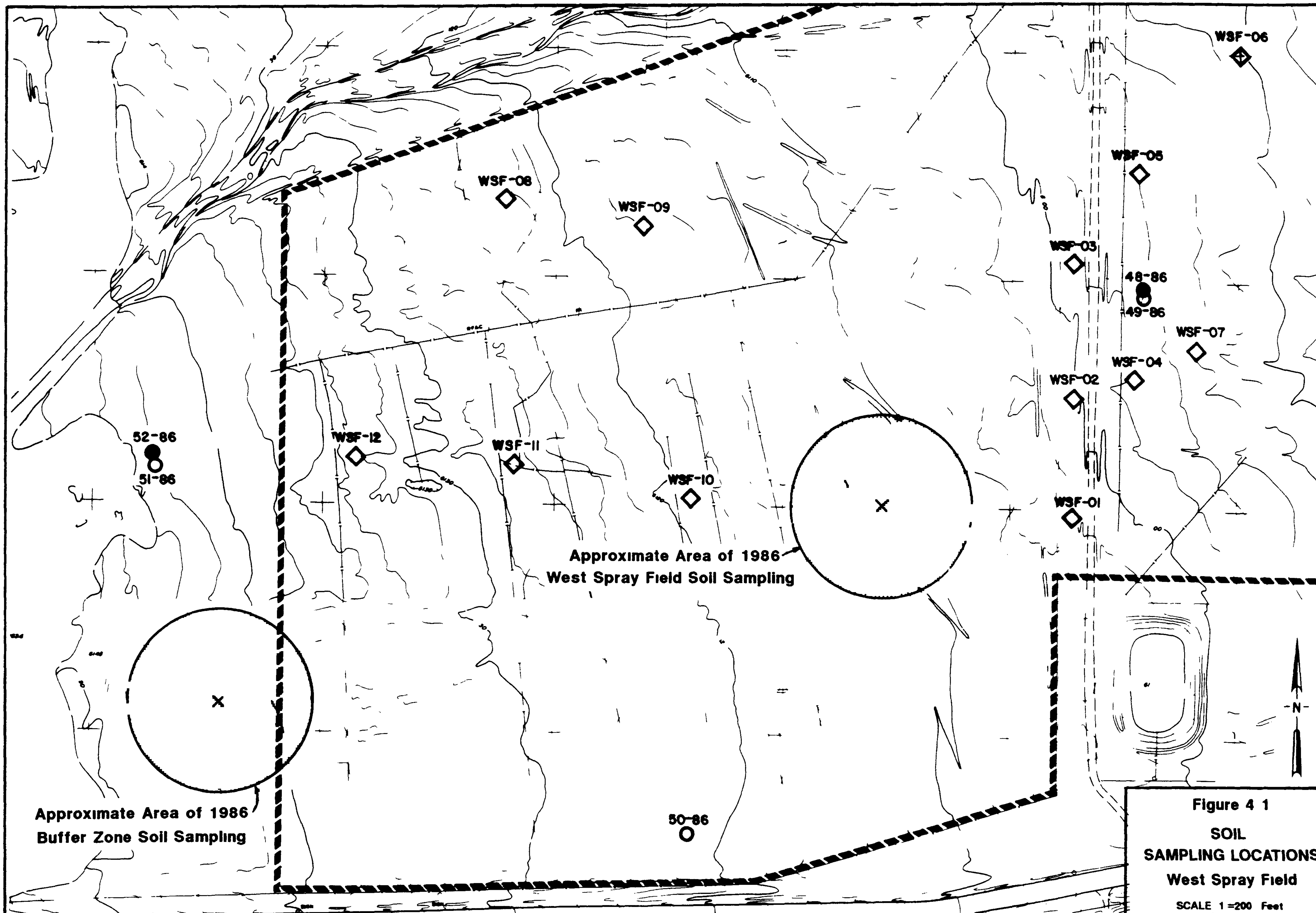
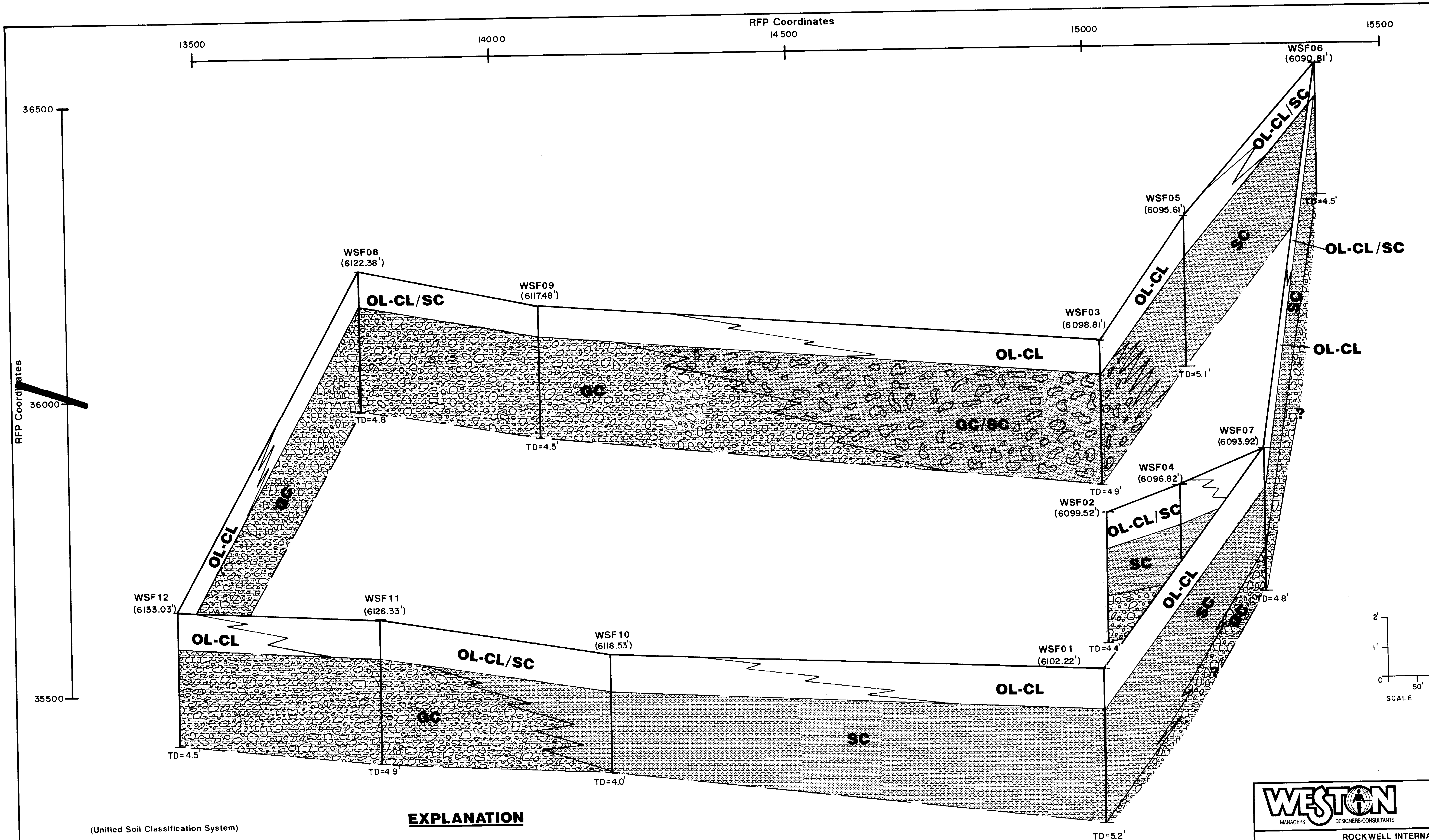


Figure 4 1
SOIL
SAMPLING LOCATIONS
West Spray Field
SCALE 1 =200 Feet



EXPLANATION

(Unified Soil Classification System)

OL	Organic silt and organic silty clays of low plasticity
CL	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay, and/or silty clay
SC	Clayey sand, sand-clay mixtures
GC	Clayey gravel, gravel-sand-clay mixtures

WSF11 — Test Pit Designation
(6126.33') — Elevation of Ground Surface

- Gravelly sandy clay or gravelly clayey sand or clayey sand and gravel or sandy clayey gravel
- Sandy clay
- Gravelly clay

TEST PIT LOGS

For the lithographic descriptions of the test pits at the West Spray Field a modified Wentworth Grain-Size Scale was used. Additionally, the Unified Soil Classification System (USCS) by B.W. Pipkin was used in describing the soils.

WESTON
MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Plate 5-3:
West Spray Field Characterization Report

Fence Diagram of Test Pits

October, 1988

EXPLANATION

51-86 ○	Alluvial Monitor Wells
52-86 ●	Bedrock Monitor Wells
WSF-11 ◇	Test Pits (1988)
⌒	Line of Equal Water Table Elevations (feet above mean sea level)
6026.78	Water Table Elevation

NOTE: 1986 Well locations resurveyed during 1988. This plate reflects new locations and elevations.

Contour Interval = 2'
SCALE: 1" = 200'
200' 0 200'

N

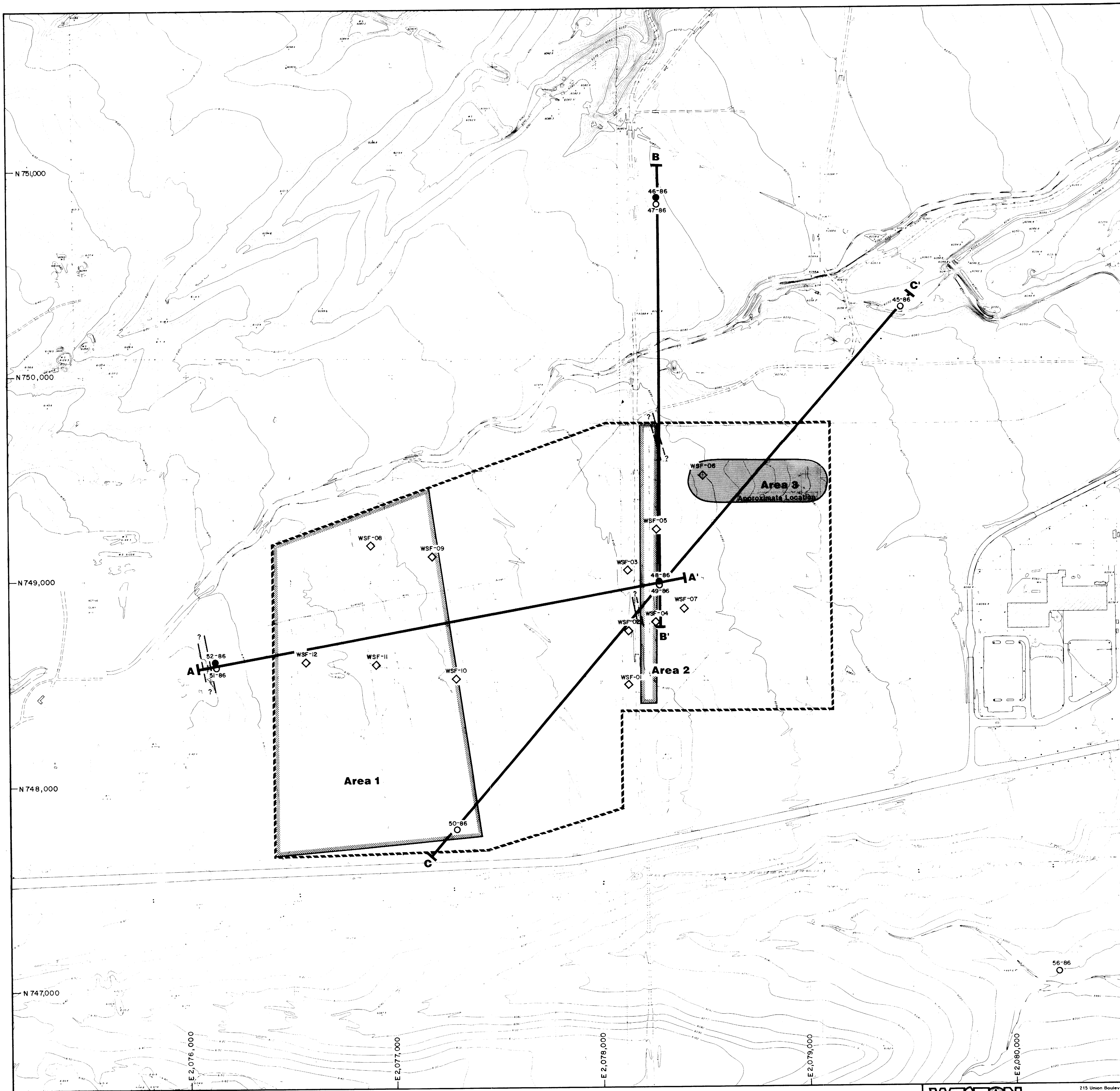
WESTON
MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Plate 5-6:
West Spray Field Characterization Report

WATER TABLE WITHIN SURFICIAL MATERIALS
MAY-1987

October, 1988



EXPLANATION

NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations.

50-86 Alluvial Monitor Well
52-86 Bedrock Monitor Well
WSF-11 Test Pits (1988)
1986 Sampling Locations
1986 Buffer Zone Sampling Locations

West Spray Field Boundary (approximate)
Spray Application Areas
Irrigation Lines
Sandstone Subcroppings
Line of Section

N

Contour Interval = 2'
SCALE: 1"=200'
200' 0 200'

WESTON
MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 500
Lakewood, Colorado 80228
(303) 980-6800

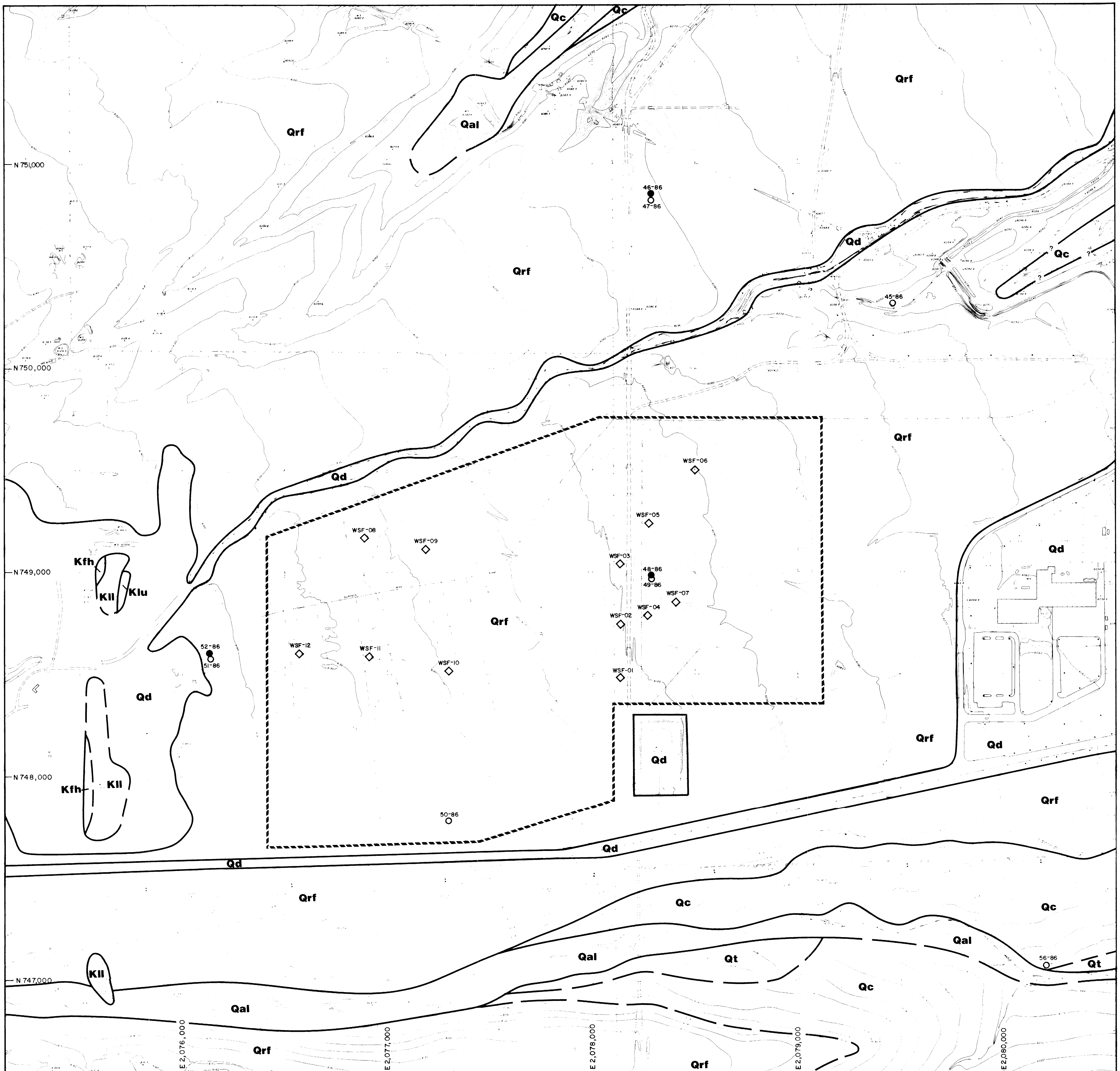
ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Plate 5-2:

West Spray Field Characterization Report

MONITOR WELL AND SAMPLING LOCATIONS, SPRAY APPLICATION AREAS, CROSS SECTION LOCATION LINES, AND SANDSTONE SUBCROPPINGS (Plan View) MAP

October, 1988



NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations.

EXPLANATION

Qd	Disturbed Ground
Qal	Recent Valley Fill
Qc	Colluvium
Qt	Terrace Alluvium
Qrf	Rocky Flats Alluvium
Klu	Laramie Formation (upper claystone unit)
Kll	Laramie Formation (lower sandstone unit)
Kfh	Fox Hills Formation
	Contact (dashed where inferred)
51-86	Alluvial Monitor Wells
52-86	Bedrock Monitor Wells
WSF-11	Test Pits (1988)

N

Contour Interval = 2'
SCALE: 1" = 200'
200' 0 200'

WESTON
MANAGERS DESIGNERS/CONSULTANTS

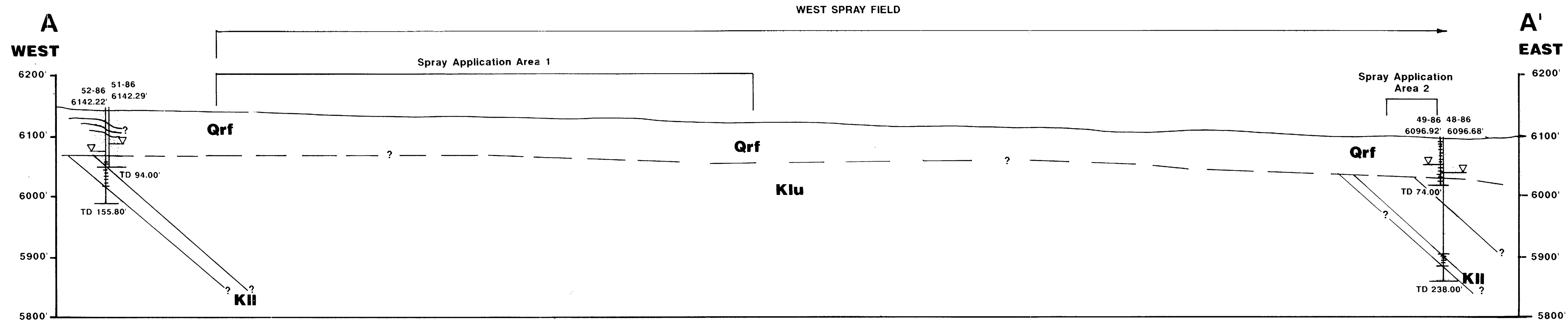
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

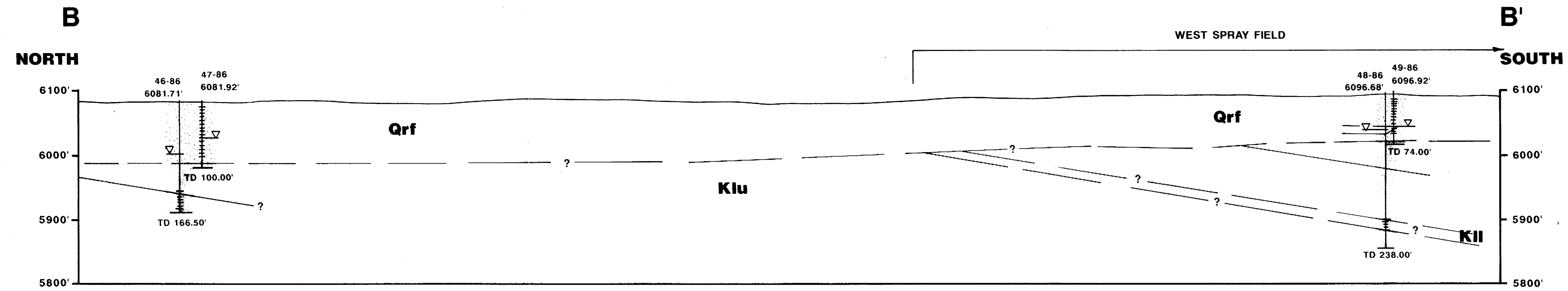
ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

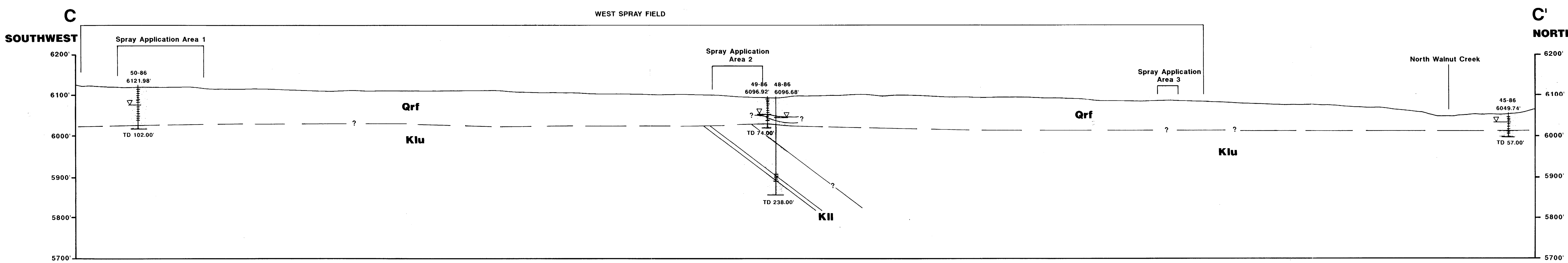
Plate 5-4:
West Spray Field Characterization Report

SURFICIAL GEOLOGY MAP

October, 1988







EXPLANATION

SCALE:

100 feet

0

100 feet

No Vertical Exaggeration

41-87 Well Identification

5931.56' Ground Surface Elevation (Surveyed)

Water level (Measured 4/11/88)

Geologic Contact (dashed where inferred)

Screened Interval

TD 110.00' Total Depth Drilled

QUATERNARY

- Qc Colluvium
- Qd Disturbed Ground
- Qrf Rocky Flats Alluvium
- Qvf Valley Fill Alluvium

CRETACEOUS

- Klu Laramie Formation (upper claystone)
- Kll Laramie Formation (lower sandstone)

- Clay
- Clayey Sand or Sandy Clay
- Sand and/or Sandstone
- Sand and/or Gravel
- Silt and/or Siltstone
- Claystone

NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations.

WESTON
MANAGERS DESIGNERS/CONSULTANTS

215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Plate 5-5:

West Spray Field Characterization Report

CROSS SECTIONS A-A', B-B', C-C',AND D-D'

October, 1988

EXPLANATION

50-86 ○ Alluvial Monitor Wells

52-86 ● Bedrock Monitor Wells

WSF-12 ◇ Test Pits (1988)

Line of Equal Water Table Elevations (feet above mean sea level)

6075.60 Water Table Elevation

NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations.

Contour Interval = 2'
SCALE: 1" = 200'

200' 0 200'

N

WESTON
MANAGERS DESIGNERS/CONSULTANTS

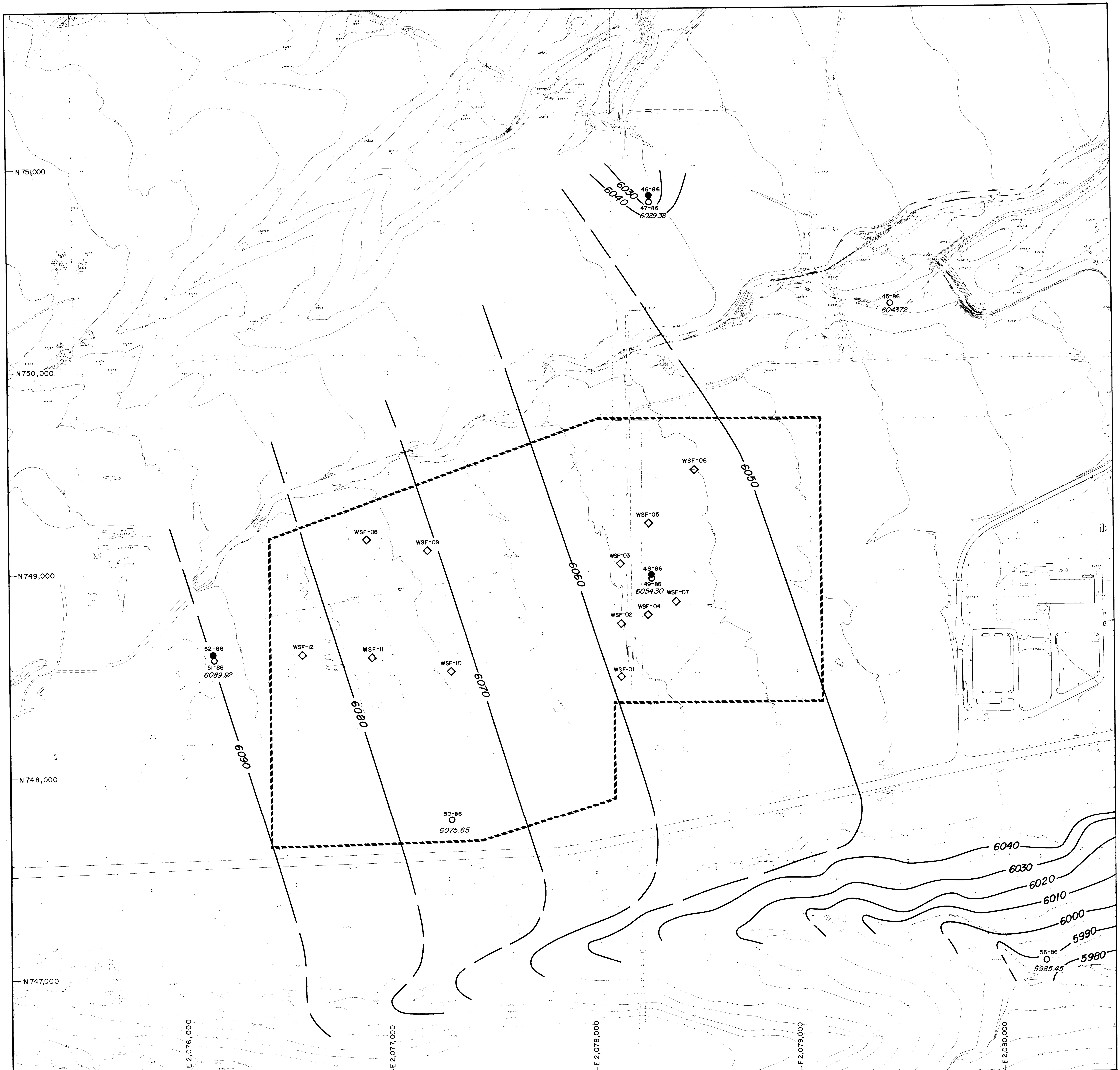
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Plate 5-7:
West Spray Field Characterization Report

WATER TABLE WITHIN SURFICIAL MATERIALS
JUNE-1987

October, 1988



EXPLANATION

51-86 Alluvial Monitor Wells

52-86 Bedrock Monitor Wells

WSF-11 Test Pits (1988)

Line of Equal Water Table Elevations (feet above mean sea level)

602678 Water Table Elevation

NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations.

N

Contour Interval = 2'
SCALE: 1" = 200'
200' 0 200'

WESTON
MANAGERS DESIGNERS/CONSULTANTS

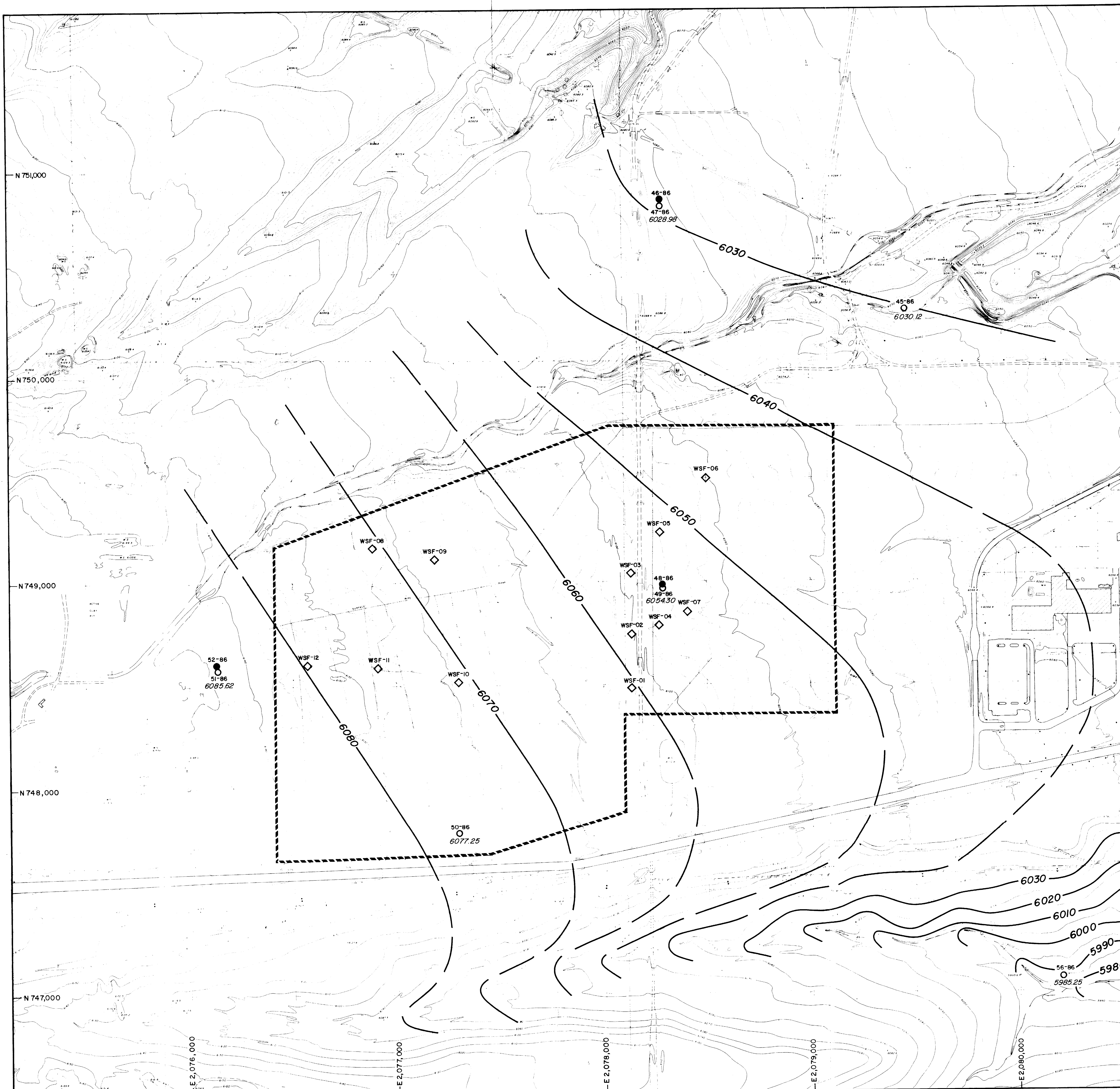
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Plate 5-8:
West Spray Field Characterization Report

WATER TABLE WITHIN SURFICIAL MATERIALS
AUGUST-1987

October, 1988



EXPLANATION

51-86 ○	Alluvial Monitor Wells
52-86 ●	Bedrock Monitor Wells
WSF-11 ◇	Test Pits (1988)
∕	Line of Equal Water Table Elevations (feet above mean sea level)
6026.78	Water Table Elevation

NOTE: 1986 Well locations resurveyed during 1988. This plate reflects new locations and elevations.

-N-

Contour Interval = 2'
SCALE: 1"=200'
200' 0 200'

WESTON
MANAGERS DESIGNERS/CONSULTANTS

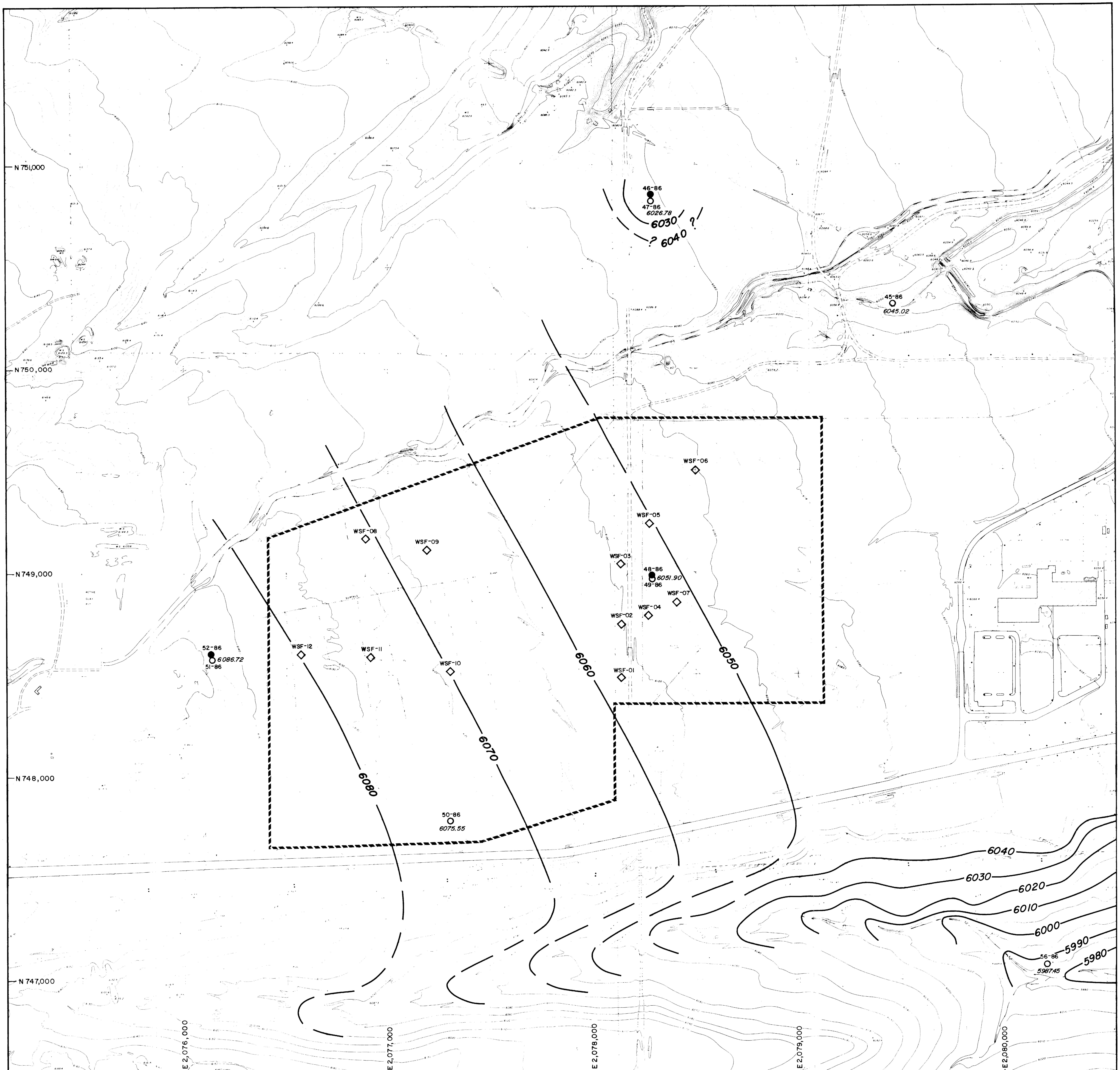
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Plate 5-9:
West Spray Field Characterization Report

WATER TABLE WITHIN SURFICIAL MATERIALS
NOVEMBER-1987

October, 1988



EXPLANATION

51-86 ○ Alluvial Monitor Wells

52-86 ● Bedrock Monitor Wells

WSF-11 ◇ Test Pits (1988)

Line of Equal Water Table Elevations (feet above mean sea level)

6026.78 Water Table Elevation

NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations.

-N-

Contour Interval = 2'
SCALE: 1" = 200'
200' 0 200'

WESTON
MANAGERS DESIGNERS/CONSULTANTS

215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Plate 5-10:
West Spray Field Characterization Report

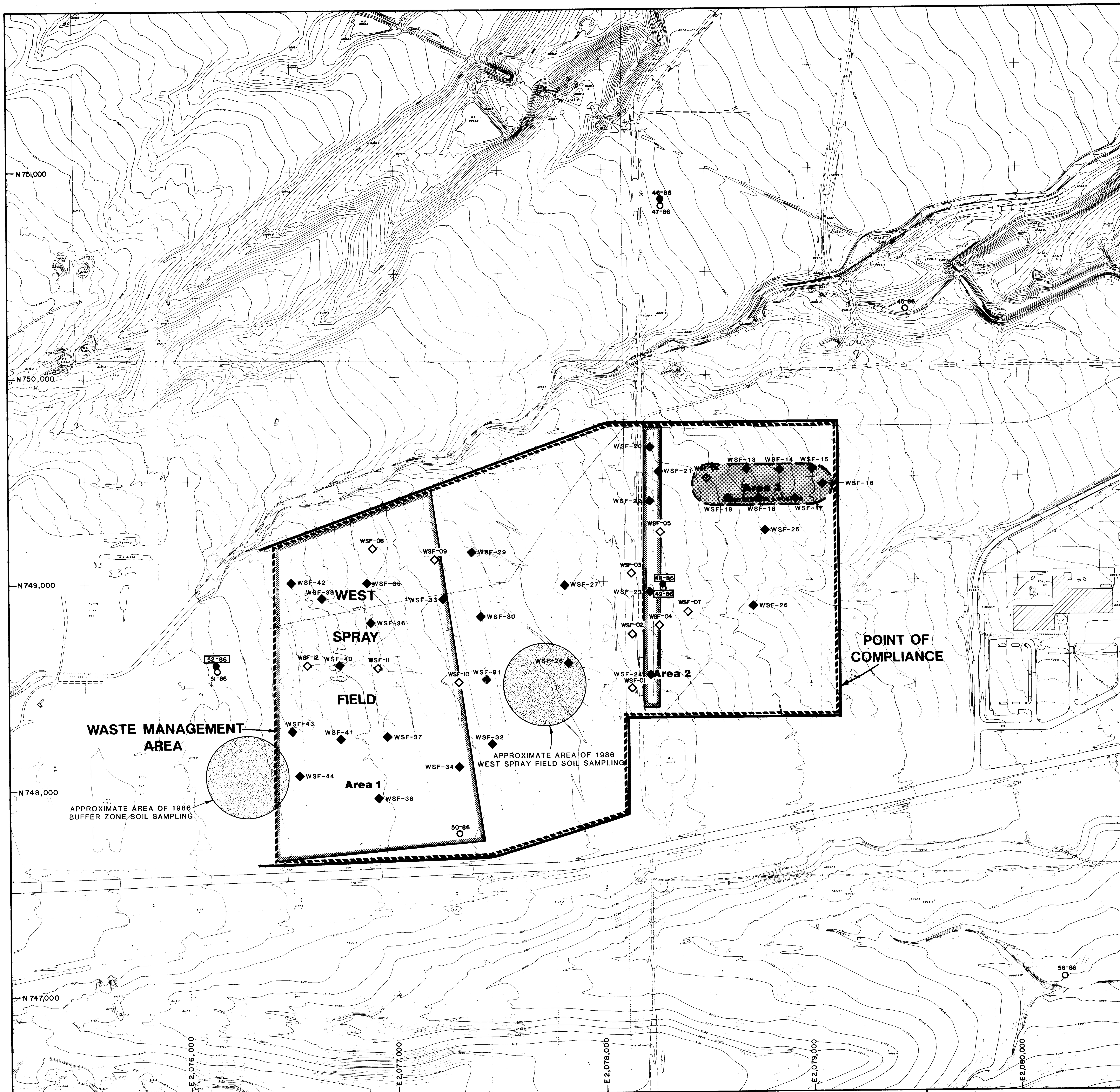
WATER TABLE WITHIN SURFICIAL MATERIALS
APRIL-1988

October, 1988

WEST SPRAY FIELD
TOPOGRAPHIC MAP

Chen & Associates
Consulting Geotechnical Engineers
96 South Zuni St. • Denver, Colorado 80223

Drawn C.L. Check A.H.	Date AUGUST, 1988	Fig. 1-2
Revised	Job Number 6 064 87	



EXPLANATION

- Spray Areas
- Point of Compliance
- Waste Management Area
- 51-86 Alluvial Monitor Well
- 46-86 Bedrock Monitor Well
- 50-86 Compliance Monitoring System
- WSF-10 Test Pits (1988)
- WSF-13 Proposed Test Pit Locations

NOTE: 1986 Well locations resurveyed during 1988. This plate reflects new locations and elevations.

Contour Interval = 2'
SCALE: 1" = 200'
200' 0 200'

N

WESTON
MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

Figure 2-1

West Spray Field
POINT OF COMPLIANCE MAP

CHEN & ASSOCIATES JOB NO. 6 064 87
October, 1988

EXPLANATION

9-87BR Bedrock Monitor Well

18-86 Alluvial Monitor Well

15-74 Existing Wells (Pre 1986)

NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations

Contour Interval: 5 feet

Scale: 1"=500'

500' 0 500' 1000 feet

Prepared by: Scharf & Associates, Inc. Denver, Colorado
from photography dated 5 20 86

WESTON
MANAGERS DESIGNERS/CONSULTANTS

215 Union Boulevard
Suite 600
Lakewood, Colorado 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

West Spray Field Characterization Report
Plate 5-1:
ROCKY FLATS PLANT
MONITOR WELL LOCATIONS

October, 1988